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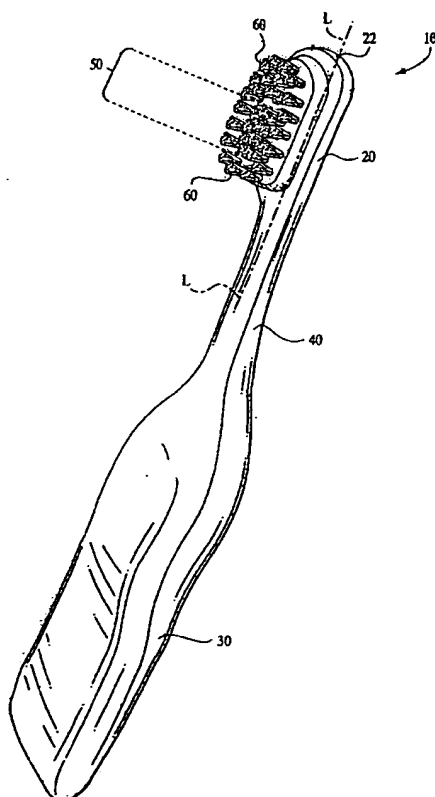
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(54) Title: HIGH EFFICIENCY ELECTRIC TOOTHBRUSH



(57) Abstract: An electric toothbrush having a particular assembly, bristle configuration, and drive mechanism is disclosed. The assembly, bristle configuration, and drive mechanism are such that operation of the brush is highly efficient and more economical than currently known toothbrushes. Specifically, an electric toothbrush is disclosed comprising a body, a head, and a neck extending therebetween. The head utilizes one of several unique and preferred arrangements of static and movable bristles. The static bristles at least partially surround the collection of movable bristles which are provided on a movable bristle carrier. A motor and drive train impart motion to the collection of movable bristles. Also disclosed is a toothbrush having a simplified and improved assembly. The toothbrush includes a unique assembly utilizing a one-piece housing in combination with a movable bristle carrier that is engaged on a brush head of the toothbrush, and a stationary brush head tip which is secured thereto. The unitary housing reduces the number of components of the toothbrush and decreases manufacturing costs. The brush head tip may be replaced with other tips and allows a consumer to individually tailor the brush to provide a particular brushing configuration as desired.

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HIGH EFFICIENCY ELECTRIC TOOTHBRUSH

Field of the Invention

The present invention relates to electric toothbrushes and more particularly, high efficiency electric toothbrushes having reduced power consumption requirements.

Background of the Invention

Although numerous reviews, investigations, and comparisons have been conducted concerning the cleaning efficacy of electric toothbrushes, few studies have been performed concerning the actual power consumption or energy efficiency of electric toothbrushes.

In 1998, Kotomin et al. reported a macromodel approach to the friction phenomena and work associated with various polymer brushes, in "Macromodel Approach to Experimental Study of Polymer Brushes Rubbing," *Wear* 222 (1998) p. 21-28. Although informative, much of that paper addressed the theoretical aspects of the mechanics of brushing and effect of bristle stiffness and frequency of oscillations upon power or energy requirements.

In the patent literature, as far as is known, the only developments that have been reported concerning power demands of electric toothbrushes are those relating to load sensor monitors that generate alarms upon excessive loading of the toothbrush. See for example, U.S. Patent 5,784,742. Moreover, other patents have described that the effectiveness of cleaning and gum massaging for sonic toothbrushes varies with torque and power levels utilized by such brushes. See U.S. Patent 5,934,908 for instance.

Although satisfactory, none of the published papers or patents are directed to new approaches for actually reducing power consumption and increasing energy efficiency of an electric toothbrush.

Toothbrushes have traditionally utilized one or more groups of bristles that are static or otherwise attached to the head or end of the toothbrush. Toothbrushes are also known that utilize movable bristle sets that are

mechanically or electrically powered. Typically, an electric motor and a drive mechanism are retained within the body of the toothbrush and are coupled to the movable bristle sets. Upon actuation of the motor and drive mechanism, the bristle sets may undergo a variety of different types of motion.

Each type of toothbrush offers certain advantages and exhibits particular characteristics, some of which the other type do not provide. Accordingly, it would be desirable to combine features and aspects of static bristles with those of movable or powered bristles.

Although toothbrushes are known in the prior art that utilize a movable or powered bristle set in combination with a static bristle set, it is believed that further improvements in cleaning efficacy and manufacturability are still attainable. Accordingly, there is a need for a toothbrush having one or more static bristle sets in conjunction with one or more movable and powered bristle sets that provides robust cleaning efficacy and which is economical and well suited for large scale manufacturing.

Currently known electric toothbrushes are relatively complex and require tedious and intricate assembly. As will be appreciated, these characteristics increase the costs associated with the toothbrush and are reflected in higher retail prices for the product. Accordingly, it would be desirable to provide an electric toothbrush that was relatively inexpensive to assemble and produce.

Modular electric toothbrushes are also known in which certain components of the brush may be interchanged or replaced with like components from other toothbrushes or components that are sold separately. For example, toothbrushes having replaceable head and neck assemblies are known in which the entire head and at least a portion of the neck may be removed from a toothbrush body or its housing, and replaced with another head and neck assembly. Although there are significant advantages to such modular systems, entire toothbrush head and neck assemblies are relatively expensive. Additionally, it is often unnecessary to replace an entire head and neck assembly with a new assembly when only the bristles are worn from the prior assembly.

Accordingly, there is a need for an alternative modular design for a toothbrush which may be tailored to a consumer's particular needs.

Summary of the Invention

In a first aspect, the present invention provides a low energy consumption, electric toothbrush comprising a housing assembly having a brush head, a handle, and a neck extending between the brush head and the handle. The housing includes a hollow interior cavity. The low energy consumption, electric toothbrush also comprises a movable bristle carrier disposed on the brush head. The toothbrush also includes a motor providing a powered rotating shaft, a drive gear secured to the shaft, and a power source electrically connected to the motor and positioned within the hollow interior cavity of the housing. The toothbrush additionally includes a crown gear supported within the cavity in the housing and configured and engaged with the drive gear of the motor in a particular fashion and at a particular gear ratio. The crown gear also includes two cam members. The toothbrush further comprises a drive shaft that is engaged with the cam members of the crown gear and with the movable bristle carrier. The toothbrush also includes a first collection of bristles retained on the movable bristle carrier and a second collection of bristles retained on the brush head. Upon operation of the motor, the crown gear is rotated which imparts a reciprocating motion to the drive shaft and to the movable bristle carrier disposed on the brush head.

In another aspect, the present invention provides an electric toothbrush comprising a housing having a handle and a brush head in which the housing includes a hollow interior region defined within it. The toothbrush also includes a movable bristle carrier positioned on the brush head. The toothbrush additionally includes a first collection of bristles supported and retained on the bristle carrier. The toothbrush further includes a second collection of bristles supported and retained on the brush head, near the bristle carrier. The toothbrush also comprises an electric motor providing a rotating shaft and power source in selectable electrical communication with the motor and positioned

within the hollow interior region of the housing. The toothbrush also includes a first drive gear affixed to the shaft of the motor. The toothbrush additionally includes a second gear engaged with the first gear and oriented such that the axis of rotation of the second gear is perpendicular to the axis of rotation of the first gear. The second gear includes an offset member positioned radially outward from the center of the second gear. The toothbrush also includes a drive shaft extending between and coupling the bristle carrier with the offset member such that, upon rotation of the second gear, a reciprocating motion is imparted to the bristle carrier. For every stroke cycle completed by the bristle carrier, the shaft of the motor rotates a certain number of times, such as from 1 to 3 times. During operation, the motor operates at a speed of from about 1500 rpm to about 3500 rpm.

In yet another aspect, the present invention provides an electric toothbrush comprising a housing having a handle, a brush head, and a neck extending between the handle and the brush head. The housing defines a hollow interior cavity. The electric toothbrush also comprises a bristle carrier movably disposed on the brush head. The toothbrush further includes a movable drive shaft coupled to the bristle carrier and movable therewith. The drive shaft extends within at least a portion of the hollow interior cavity defined in the housing. The toothbrush also comprises a first set of bristles disposed on the carrier and movable therewith. The toothbrush further includes a motor and power source disposed in the hollow interior cavity of the housing in which the motor provides a powered output shaft. The electric toothbrush further comprises a gearing assembly disposed in the hollow interior cavity and engaged with the shaft of the motor and the drive shaft such that upon operation of the motor, a reciprocating motion is imparted to the drive shaft and the bristle carrier. The toothbrush also comprises a second collection of stationary bristles disposed on the brush head. The motor exhibits the following current draw characteristics: (i) about 0.3 amps without a load, and (ii) from about 0.4 amps to about 0.6 amps under a typical brushing load. The motor operates at a speed of from about 1500 rpm to about 3500 rpm.

In a further aspect, the present invention provides a low energy

consumption electric toothbrush comprising a housing assembly including a brush head, a handle, and a neck extending between the brush head and the handle. The housing defines a hollow interior cavity. The electric toothbrush further comprises a movable bristle carrier disposed on the brush head. The toothbrush also comprises a motor providing a powered rotating shaft, a drive gear affixed to the shaft, and a power source in the form of a single (AA) battery. The power source is in electrical communication with the motor and disposed in the hollow interior cavity. The power source provides a voltage source of from about 0.9 volts to about 2.5 volts. The toothbrush also comprises a crown gear rotatably supported in the hollow interior cavity and engaged with the drive gear of the motor. The crown gear includes an offset member disposed radially outward from an axis of rotation of the crown gear. The electric toothbrush further comprises a drive shaft having a first end and a second opposite end. The first end is engaged with the offset member of the crown gear, and the second end is engaged with the movable bristle carrier. The toothbrush also comprises a first plurality of bristles retained on the movable bristle carrier, and a second plurality of stationary bristles retained on the brush head. Upon operation of the motor, the crown gear is rotated thereby imparting a reciprocating motion to the drive shaft and to the movable bristle carrier disposed on the brush head. The toothbrush exhibits a total run time upon application of a one pound load to the first and second collection of bristles on the brush head, of at least 100 minutes.

In yet another aspect, the present invention provides an electric toothbrush comprising a housing having a brush head and a handle. The housing defines an interior hollow cavity. The electric toothbrush also comprises a movable bristle carrier disposed on the brush head. The electric toothbrush also comprises a power source in the form of a single (AA) battery disposed in the hollow cavity. The battery provides a voltage source of from about 0.9 volts to about 2.5 volts. The toothbrush also comprises a motor in selective electrical contact with the power source. The motor is disposed in the hollow interior cavity. The electric toothbrush also comprises a drive train disposed in the hollow cavity and engaged with the motor and the movable bristle carrier such

that, upon operation of the motor, the bristle carrier undergoes a reciprocating motion.

Brief Description of the Drawings

The present invention may take form in various components and arrangements of components, and in various techniques, methods, or procedures and arrangements of steps. The referenced drawings are only for purposes of illustrating preferred embodiments, they are not necessarily to scale, and are not to be construed as limiting the present invention.

It is believed that the present invention will be better understood from the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a perspective view of a preferred embodiment toothbrush in accordance with the present invention.

Fig. 2 is a detailed view showing a preferred embodiment arrangement of various bristle types according to the present invention.

Fig. 3 is another preferred embodiment of a preferred configuration of bristle arrangements according to the present invention.

Fig. 4 is another preferred embodiment of bristle arrangements according to the present invention.

Fig. 5 is yet another preferred embodiment of bristle arrangements according to the present invention.

Fig. 6 is a partial cross-sectional view showing a preferred embodiment brush head according to the present invention.

Fig. 7 is a partial cross-sectional view showing another preferred embodiment brush head according to the present invention.

Fig. 8 is a partial cross-sectional view of yet another preferred embodiment brush head according to the present invention.

Fig. 9 is a partial cross-sectional view of a further preferred embodiment brush head according to the present invention.

Fig. 10 is a detailed perspective view of a cam assembly according to a preferred embodiment of the present invention.

Fig. 11 is a detailed perspective view of another preferred embodiment cam arrangement according to the present invention.

Fig. 12 is a perspective view showing a partial assembly of another preferred embodiment toothbrush in accordance with the present invention.

Fig. 13 is a detailed view showing a preferred configuration of bristle arrangements according to the present invention.

Fig. 14 is another preferred embodiment of bristle arrangements and illustrating a manner of designating locations of certain bristles, according to the present invention.

Fig. 15 is another preferred embodiment of bristle arrangements according to the present invention.

Fig. 16 is a detailed view of a preferred embodiment brush head according to the present invention.

Fig. 17 is a side view of the brush head shown in Fig. 16.

Fig. 18 is a detailed view of another preferred embodiment brush head according to the present invention.

Fig. 19 is a side view of the brush head shown in Fig. 18.

Fig. 20 is a perspective view of another preferred embodiment toothbrush in accordance with the present invention.

Fig. 21 is a partial exploded perspective view of the preferred embodiment toothbrush illustrated in Fig. 20, illustrating certain components and their assembly to form the preferred embodiment toothbrush.

Fig. 22 is a detail view illustrating the assembly of a preferred embodiment toothbrush head of the preferred embodiment brush shown in Figs. 21 and 22.

Fig. 23 is another detail view of the toothbrush head of Fig. 22 illustrating further assembly of components therein.

Fig. 24 is another detail view of the toothbrush head of Figs. 22 and 23, again illustrating further assembly of components therein.

Fig. 25 is a partial side elevational view of the toothbrush head of the preferred embodiment brush illustrating one possible bristle configuration in accordance with the present invention.

Fig. 26 is an end view of the toothbrush head taken along line 26-26 in Fig. 25.

Fig. 27 is a partial side elevational view of a toothbrush head of another preferred embodiment toothbrush illustrating another bristle configuration in accordance with the present invention.

Fig. 28 is an end view of the toothbrush head shown in Fig. 27 taken along line 28-28.

Fig. 29 is a partial side elevational view of another preferred embodiment toothbrush illustrating yet another preferred bristle configuration in accordance with the present invention.

Fig. 30 is an end view of the toothbrush head shown in Fig. 29 taken along line 30-30.

Fig. 31 is an end view of another preferred embodiment toothbrush head illustrating another bristle configuration in accordance with the present invention.

Fig. 32 is an end view of a further preferred embodiment toothbrush head in accordance with the present invention illustrating yet another preferred bristle configuration.

Fig. 33 is an end view of yet another preferred embodiment toothbrush head in accordance with the present invention illustrating another bristle configuration.

Fig. 34 is a partial side elevational view of another preferred embodiment toothbrush head in accordance with the present invention illustrating another preferred bristle configuration.

Fig. 35 is a partial side elevational view of another preferred embodiment toothbrush head in accordance with the present invention illustrating another preferred bristle configuration.

Fig. 36 is a partial side elevational view of another preferred embodiment toothbrush head in accordance with the present invention illustrating another preferred bristle configuration.

Fig. 37 is a partial side elevational view of another preferred embodiment toothbrush head in accordance with the present invention illustrating another preferred bristle configuration.

Fig. 38 is a partial side elevational view of another preferred embodiment toothbrush head in accordance with the present invention illustrating another preferred bristle configuration.

Fig. 39 is a partial side elevational view of another preferred embodiment toothbrush head in accordance with the present invention illustrating another preferred bristle configuration.

Fig. 40 is a partial side elevational view of another preferred embodiment toothbrush head in accordance with the present invention illustrating another preferred bristle configuration.

Fig. 41 is a partial side elevational view of another preferred embodiment toothbrush head in accordance with the present invention illustrating another preferred bristle configuration.

Fig. 42 is a partial side elevational view of another preferred embodiment toothbrush head in accordance with the present invention illustrating another preferred bristle configuration.

Fig. 43 is a partial side elevational view of another preferred embodiment toothbrush head in accordance with the present invention illustrating another preferred bristle configuration.

Fig. 44 is a partial side elevational view of another preferred embodiment toothbrush head in accordance with the present invention illustrating another preferred bristle configuration.

Fig. 45 is a partial side elevational view of another preferred embodiment toothbrush head in accordance with the present invention illustrating another preferred bristle configuration.

Fig. 46 is a planar detail view of a toothbrush head (without bristles) of another preferred embodiment toothbrush according to the present invention.

Fig. 47 is a cross-sectional view of the toothbrush head illustrated in Fig. 46, taken across line 47-47.

Fig. 48 is a partial exploded view of another preferred embodiment toothbrush in accordance with the present invention.

Fig. 49 is a partial exploded view of another preferred embodiment toothbrush in accordance with the present invention.

Fig. 50 is a perspective view of a portion of a preferred embodiment drive mechanism in accordance with the present invention.

Fig. 51 is a side elevational view of the portion of the preferred embodiment drive mechanism illustrated in Fig. 50.

Fig. 52 is a perspective view of a preferred embodiment brush head and neck of a toothbrush in accordance with the present invention.

Fig. 53 is a planar view of another preferred embodiment brush head and neck of a toothbrush in accordance with the present invention.

Fig. 54 is a planar view of yet another preferred embodiment brush head and neck of a toothbrush in accordance with the present invention.

Fig. 55 is a partially exploded view of a preferred embodiment engagement assembly for converting rotary motion to reciprocating motion, preferably utilized in the present invention toothbrushes.

Fig. 56 is a top planar view of a gear of the preferred assembly depicted in Fig. 55.

Fig. 57 is a side elevational view of the gear shown in Fig. 56.

Fig. 58 is a partial cross-sectional view of the preferred assembly of Fig. 55 illustrating the engagement between a drive shaft and the gear.

Fig. 59 illustrates the underside of an end of the drive shaft of the assembly of Fig. 55.

Fig. 60 is a top, planar view of the assembly of Fig. 55 illustrating the operation of that assembly.

Detailed Description of the Preferred Embodiments

The present invention is based upon a discovery that significant cleaning efficacy results from a toothbrush that utilizes a combination of static

bristles and movable bristles that are powered. Preferably, the movable bristles reciprocate when powered, and most preferably, the movable bristles reciprocate in a direction generally parallel to the longitudinal axis of the toothbrush. It is contemplated that the movable bristles may also reciprocate in a direction generally perpendicular to the longitudinal axis. Although reciprocation is the preferred type of movement for the movable bristle holder, the present invention encompasses other types of movement for the movable bristle holder. In all of the preferred embodiments described herein, the various movable bristles are all powered or carried by a single movable component. This is described in greater detail herein. The present invention is also based upon a discovery of particular patterns or configurations for the static bristles, particularly when utilized in conjunction with the movable and powered bristle set. Furthermore, the present invention toothbrush, featuring a moveable bristle holder that reciprocates and which is at least partially surrounded by an array of static bristles, is particularly well suited for large scale manufacturing. That is, the various preferred embodiment brushes described herein are relatively inexpensive to manufacture as a result of their remarkable simplicity and novel structure. These and other aspects are described herein.

The present invention is also based upon a unique design for a unitary body or housing for an electric toothbrush that incorporates an integral neck and brush head assembly. The one-piece body or housing greatly simplifies assembly of the toothbrush and reduces manufacturing costs associated with the brush. The present invention also provides a novel modular design for the brush head that enables a wide array of bristle sets to be used in conjunction with the toothbrush.

Furthermore, as described herein, certain preferred embodiments include elastomeric tips or flexible, outwardly extending members that are disposed on the brush head. The static portion and the moving portion of the brush head also may include elastomeric tips along with the bristles. The static portion and the moving portion can each include bristles and elastomeric tips, which are used for gently massaging the user's gums while brushing. The elastomeric tips can be located on the perimeter of the static and moving portions

or among the bristles on the static and moving portions of the brush head.

Referring to Fig. 1, a preferred embodiment toothbrush 10 according to the present invention is illustrated. The toothbrush 10 comprises a body 30, a head 20 and a neck 40 extending between the body 30 and the head 20. The head 20 defines a distal-most end 22. The head 20 and the neck 40 generally extend along a longitudinal axis illustrated in Fig. 1 as axis L. Disposed along the head 20 are a plurality of static bristles 60 and a collection of interiorly disposed bristles 50 which are movable as described herein. The bristles 50 are supported on and retained by a movable bristle holder. The movable bristle holder may undergo a wide variety of motions as noted below.

Before describing the various preferred embodiments, it is instructive to define the various types of motions that the movable bristles may undergo. As used herein, the term "angular motion" refers to any angular displacement. "Linear motion" is movement along a straight or substantially straight, line or direction. "Primarily linear motion" is described below. "Curvilinear motion" is movement that is neither completely linear nor completely angular but is a combination of the two (e.g., curvilinear). These motions can be constant or periodic. Constant motion refers to motion that does not change direction or path (i.e., is unidirectional). Periodic motion refers to motion that reverses direction or path. Constant angular motion (i.e., motion that extends through 360 degrees or more) that is substantially in the form of a circle is referred to as rotary motion. Periodic angular motion is motion that extends through less than 360 degrees and is referred to as oscillating motion. Curvilinear motions can also be either constant (i.e., unidirectional) or periodic (i.e., reverses direction). Periodic linear motion is referred to as "reciprocation". The above-described motions can also occur along one or more axes of a bristle holder.

Furthermore, it is useful to define the term "static" bristles and the term "movable" bristles. The term static bristles refer to bristles that are secured or static to the brush head or body of the toothbrush or other component thereof so that the bristles, and specifically, the base of the bristles, do not move with regard to the toothbrush. Restated, static bristles refer to bristles that are fixed to the toothbrush such that their base or point of attachment does not move with

respect to the toothbrush. It is recognized that the tips or regions distal from the base of a bristle or group of bristles may move as a result of flexing of the bristle. However, the base of a static bristle does not move with respect to the brush. The term movable bristle refers to a bristle in which the base of the bristle moves with respect to the toothbrush, and preferably with respect to the longitudinal axis of the brush. Generally, this configuration is accomplished by affixing or supporting the base of the bristle to a mounting component, i.e. a bristle carrier or holder, that is movable with respect to the brush. Restated, a movable bristle is a bristle that is movable, and preferably with respect to the longitudinal axis of the brush.

Figs. 2-5 and 13 illustrate various preferred embodiment configurations for the arrangement of the static bristles and the movable bristles. Fig. 2 is a detail view of the toothbrush 10 shown in Fig. 1 and its head 20. As can be seen from Fig. 2, the static bristles 60 generally extend entirely around the collection of movable bristles 50. The movable bristles 50 are disposed and situated on a movable bristle holder 52. The bristle holder 52 is preferably movable between two positions shown in Fig. 2 as position A and position B. Preferably, the bristle holder 52 may be moved back and forth between position A, in which the bristle holder 52 is proximate the distal-most end 22 of the brush head 20, and position B shown in Fig. 2 by dashed lines. Most preferably, the direction of movement of the bristle holder 52 as it reciprocates between positions A and B is generally parallel to the longitudinal axis of the head 20 and neck (not shown in Fig. 2) as noted in Fig. 1 as axis L.

Fig. 3 illustrates another preferred arrangement of bristles along a brush head 120 of a preferred embodiment toothbrush 100. In this embodiment, a plurality of static bristles 160 extend substantially around the periphery or perimeter of a collection of movable bristles 150. The movable bristles 150 are supported and retained along a movable bristle holder 152. The bristle holder 152 is movable between two positions A and B shown in Fig. 3. In this preferred configuration, the region 125 along the brush head 120 does not contain any bristles, either static bristles or movable bristles. As previously described with respect to Fig. 2, the bristle holder 152, and thus movable bristles 150, preferably

may reciprocate between positions **A** and **B**. As will be noted from Fig. 3, position **A** is proximate the distal-most end **122** of the brush head **120**.

Fig. 4 illustrates another preferred embodiment toothbrush head **220** of a toothbrush **200** according to the present invention. In this embodiment, a collection of static bristles **260** are located at opposite regions of the brush head **220** around a collection of movable bristles **250**. The movable bristles **250** are supported and retained along a movable bristle holder **252**. The movable bristle holder **252** is movable between position **A** and position **B** as shown in Fig. 4. It will be noted that two regions are defined, between the collection of static bristles **260**, which do not contain any bristles. These regions are designated in Fig. 4 as regions **227**, **229**. As previously noted with respect to Fig. 2, the bristle holder **252**, and thus the movable bristles **250**, preferably may reciprocate between positions **A** and **B**. Position **A** is proximate the distal-most end **222** of the brush head **220**.

Fig. 5 illustrates yet another preferred embodiment toothbrush head **320** of a toothbrush **300** in accordance with the present invention. In this embodiment, a collection of static bristles **360** extend only partially around a collection of movable bristles **350** supported and retained on a movable bristle holder **352**. The movable bristle holder **352** is movable between two positions shown in Fig. 5 as positions **A** and **B**. It will be noted that regions **329**, **327**, **325** are defined around the periphery of the collection of movable bristles **350**. These regions do not contain any bristles and particularly do not contain any static bristles **360**. As previously noted with regard to Fig. 2, the bristle holder **352**, and thus the movable bristles **350**, preferably may reciprocate between positions **A** and **B**. Position **A** is proximate the distal-most end **322** of the brush head **320**.

Fig. 13 illustrates another preferred embodiment toothbrush head **920** of a toothbrush **900** according to the present invention. In this embodiment, a collection of static bristles **960** are located at opposite regions of the brush head **220** around a collection of movable bristles **950**. Specifically, the static bristles **960** are located along the sides of the brush head **920**. Regions **925** and **927** are defined between the groups of static bristles, and preferably as shown in Fig. 13. The movable bristles **950** are supported and retained along a movable

bristle holder **952**. The movable bristle holder **952** is movable between position **A** and position **B** as shown in Fig. **13**. As previously noted with respect to Fig. **2**, the bristle holder **952**, and thus the movable bristles **950**, preferably may reciprocate between positions **A** and **B**. Position **A** is proximate the distal-most end **922** of the brush head **920**.

It will be noted that the preferred bristle configurations are based upon the movable bristles located generally within a middle region or interior of the brush head, and static bristles at least partially surrounding the medially disposed movable bristles. This is explained in greater detail herein.

For certain applications, it is preferred that the static bristles surround 100% of the perimeter or periphery of the collection of movable bristles. In other applications, it is preferred that the static bristles surround or extend along about 75% to about 100% of the perimeter of the movable bristles. In still other applications, it is preferred that the static bristles extend along about 50% to about 75% of the perimeter of the movable bristles. In further applications, it is preferred that the static bristles extend along about 25% to about 50% of the perimeter of the movable bristles. And in other applications, it may be preferred that the static bristles extend less than 25% around the perimeter of the movable bristles. As noted, the static bristles preferably extend along at least a portion of the outer periphery of the collection of movable bristles. It is not necessary for certain embodiments that the static bristles extend continuously about the periphery of the set of movable bristles. That is, the present invention encompasses bristle configurations in which the static bristles extend intermittently along or about the outer periphery of the collection of movable bristles.

The terms "completely encircling (or encircle)", "substantially encircling (or encircle)", "partially encircle (or encircle)", and "partially surrounding (or surround)" are used herein to refer to particular configurations of static bristles and their relative location with respect to the movable bristles. The term "completely encircling" refers to a configuration in which the static bristles completely encircle, or are located entirely around, the perimeter of the movable bristles. It will be understood that when static bristles are described as encircling

or extending along the perimeter or portion thereof of the movable bristles, minute or relatively small spaces may exist between individual bristles or groups of bristles. These spaces are on the order of only 1 to 10 diameters of a typical bristle. The term "substantially encircling" refers to a configuration in which the static bristles extend along at least 80% of the perimeter of the movable bristles. Specifically, substantially encircle includes configurations in which the static bristles extend along 80% or more, 90% or more, or 95% or more of the perimeter of the movable bristles. The term "partially encircling" refers to a configuration in which the static bristles extend along a portion of the perimeter of the movable bristles, and preferably, extend along a portion that is less than 80% of the distance along that perimeter. The term "partially surrounding" refers to a configuration in which the static bristles partially surround, and do not completely or entirely surround, the movable bristles.

As noted, the movable bristle holder may undergo a wide variety of motions. For example, the movable bristle holder may undergo angular motion, linear motion, or curvilinear motion. The movement of the bristle holder may be constant or periodic. Generally, the preferred motion for the movable bristle holder is periodic linear motion or reciprocation.

The movable bristle holder may be in a variety of forms and shapes. The preferred shape for the movable bristle holder is oval, such as generally shown in the referenced figures, such as in Figs. 2-5. It is generally preferred that the movable bristle holder is elongated in shape, more preferably oval, and most preferably, have proportions according to a certain range of ratios of length to width dimensions. Most preferably, the movable bristle holder is in the shape of an oval and has a length (as measured along a major axis of its oval shape) to width (as measured along a minor axis of its oval shape) of from about 4:1 to about 1.2:1. The width of the movable bristle holder (again, as measured along a minor axis of its oval shape), approaches the width of the brush head, at that location along the brush head. For those embodiments of the present invention in which the bristle holder is oval-shaped, and in which the bristle holder moves in a reciprocating fashion, the holder is oriented such that movement occurs generally parallel to the major axis of the oval shape. Preferably, the width of the

movable bristle holder is from about 50% to about 90% of the width of the brush head, and most preferably from about 60% to about 80%.

Referring to Fig. 6, another preferred embodiment of a head 420 for a toothbrush 400 will now be described. The head 420 includes an inner bristle holder 452 that is slideably mounted in slots defined along the head 420. The inner bristle holder 452 supports and retains a plurality of movable bristles 450. The inner bristle holder 452 is reciprocatingly driven in the same general longitudinal direction as the longitudinal axis of the head 420. The inner bristle holder 452 and bristles 450 are preferably at least partially surrounded by an array of static bristles shown in Fig. 6 by dashed lines. The toothbrush 400 includes an electric motor (not shown) and a drive mechanism, the drive shaft of which is illustrated in Fig. 6 as shaft 460. A cam 470 engaged with the shaft 460 operatively interconnects the shaft 460 with inner bristle holder 452. Optionally, the shaft 460 can be supported by shaft supports 465. The shaft supports 465 may include C or U shaped portions (not shown) that receive the shaft 460. Other means for retaining the shaft 460 in a support are known in the art. The cam 470 can comprise a shaped element or bead, with an appropriate eccentric configuration, placed or molded over and firmly secured to the shaft 460. In one arrangement, the cam 470 is cylindrically shaped with a pair of acutely angled surfaces 472, 473 which are inclined in the same direction and at the same angle of inclination, but which are disposed at opposite ends of the cam 470. In other words, the angled surfaces 472, 473 are the surfaces resulting from a diagonal slice through the cylinder of the cam 470. The direction of inclination and angle of inclination can be varied as desired to change the frequency and stroke of the inner bristle holder 452. First and second cam followers 454, 456 are provided that are secured to or extend from the underside 453 of the bristle holder 452. The cam followers 454, 456 are offset or spaced from each other so that cam 470 is disposed between the cam followers 454, 456 which straddle and/or capture the cam 470. The angled surfaces 472, 473 of the cam 470 slidably engage the free ends of the cam followers 454, 456. As the shaft 460 rotates, the first acutely angled surface 472 of the cam 470 comes into contact with a surface of the first cam follower 454 and drives the cam follower, and therefore, the inner

bristle holder **452**, away from the end **422** in a direction generally the same as the direction of the longitudinal axis of the head **420**. The inner bristle holder **452** is guided by the longitudinally extending slots. As the shaft **460** continues to rotate, the cam **470** disengages from the first cam follower **454**. The second acutely angled second surface **473** of the cam **470** then comes into contact with a surface of the second cam follower **456** and drives the second cam follower **456**, and therefore the inner bristle holder **452**, back toward the end **422** of the head **420**.

Referring to Figs. 7 and 8, another embodiment of a toothbrush head **520** suitable for use with an electric toothbrush **500** will now be described. The head **520** includes an inner bristle holder **552** that is slideably mounted in slots (not shown) defined in the head **520**. The inner bristle holder **552** supports and retains a plurality of bristles **550**. The inner bristle holder **552** is reciprocatingly driven in the same general longitudinal direction as the longitudinal axis of the head **520**. The toothbrush **500** includes a motor (not shown) and a drive mechanism that includes a rotating drive shaft **560**. The head **520** extends from a neck **540** and has a distal-most end **522**. A cam **570** included on the shaft **560** operatively interconnects the shaft **560** with inner bristle holder **552**. Optionally, the shaft **560** can be supported by shaft supports **565**. The shaft supports **565** may include C or U shaped portions (not shown) that receive the shaft **560**. Other means for retaining the shaft **560** in a support are known in the art. The cam **570** is provided in the form of a plurality of bends **572**, **573** in the shaft **560**. The bends are sinusoidal or curvilinear in nature in that each bend has one or more adjacent arcuate portions. The bends each have an apex and the apexes are disposed on opposite sides of the shaft **560**. A hemispherically-shaped cam follower **554** depends from a bottom surface **553** of the inner bristle holder **552** and is disposed between the apexes of the cam **570**. As the shaft **560** rotates, a surface **576** of the cam **570** comes into contact with a first surface **555** of the cam follower **554** and drives the cam follower **554**, and therefore the inner bristle holder **552**, away from the end **522** in a longitudinal direction generally the same as the longitudinal axis of the head **520**. As the shaft **560** continues to rotate, the cam surface **576** disengages from the first cam follower surface **555**. As shown

in Fig. 8, the cam surface **576** then comes into contact with a second surface **556** of the cam follower **554** and drives the cam follower **554**, and therefore the inner bristle holder **552**, back toward the end **522**. The motion of the bristle holder **552** can be varied by changing the spacing between the apexes **572**, **573** and/or the amplitude, shape, or height of the apexes **572**, **573**, length and inclination of the cam surface **576**, and inclination of the surfaces **555**, **556** of the cam follower **554**.

Referring to Fig. 9, another embodiment of a toothbrush head **620** for an electric toothbrush **600** will now be described. The head **620** includes an inner bristle holder **652** that is slideably mounted in slots (not shown) defined in the head **620**. The head **620** includes a distal end **622**. The inner bristle holder **652** supports and retains a plurality of bristles **650**. The inner bristle holder **652** is reciprocatingly driven in the same general longitudinal direction as the longitudinal axis of the head **620**. The toothbrush **600** includes a motor (not shown) and a drive mechanism that includes a rotating drive shaft **660**. A cam **670** included on the shaft **660** operatively interconnects the shaft **660** with the inner bristle holder **652**. Optionally, the shaft **660** can be supported by shaft supports **665**. The shaft supports **665** may include C or U shaped portions (not shown) that receive the shaft **660**. Other means for retaining the shaft **660** in a support are known in the art. The cam **670** is provided in the form of a cylindrically-shaped component **674** placed or molded over and firmly secured to the shaft **660**.

As shown in Fig. 10, the cam **670** includes a spiral or helical groove **672** defined along the outer surface of the cylindrically shaped component **674**. The spiral or helical groove **672** preferably extends around the circumference of the component **674** and spirals about a longitudinal axis of the component **674** which may, for example, coincide with the longitudinal axis of the shaft **660**. The stroke and frequency of the motion imparted to a cam follower **654** (shown in Figs. 9 and 10) by the cam **670** can be varied by changing the shape and dimensions of the groove **672**. For example, the groove **672** defined in the component **674** would provide one complete stroke of the inner bristle holder **652** (i.e., one cycle away from and back toward the end of the head **622**) for one

revolution of the shaft 660.

Fig. 11 illustrates an alternate cam 770 having a helical groove 772 which is provided in the form of a figure eight. This would only provide one-half a stroke (i.e., only either translation toward or away from the end of the brush head) for one revolution of the shaft 760. A cam follower 754 is disposed in the groove 772 and is engaged to a movable bristle holder.

Returning to Figs. 9 and 10, a cam follower 654 depends from a bottom surface 653 of the inner bristle holder 652. The cam follower 654 is slideably received within the groove 672. As the shaft 660 rotates, a first surface 675 of the spiral groove 672, such as a side wall thereof, comes into contact with a first surface of the cam follower 654 and drives the cam follower 654 and therefore the inner bristle holder 652, away from the end 622 of the brush head 620, in a longitudinal direction generally the same as the longitudinal axis of the head 620. As the shaft 660 continues to rotate, the cam follower 654 reaches an apex of the spiral groove 672 and the first surface 675 of the spiral groove 672 disengages from the cam follower 654. A second surface 676 of the groove 672, such as the opposite side wall of the groove 672, then comes into contact with the cam follower 654 and drives the cam follower 674, and therefore the inner bristle holder 652, back toward the end 622 of the brush head 620.

The various reciprocating bristle holders described herein may also utilize a drive mechanism that provides a shaft that rotates. Furthermore, it will be appreciated that other motor and reciprocating or rotating shaft arrangements can be substituted. For example, US Patent Nos. 5,226,206; 5,524,312; 5,383,242; 5,465,444; 5,504,959; 5,836,030; 4,845,795; 5,404,608; 5,359,747; and 5,617,601, the substances of which are incorporated herein by reference, disclose other motor and reciprocating shaft arrangements that might be suitable. In addition, the electric toothbrush of Fig. 9 might be provided with a replaceable head. A suitable arrangement which can be adapted to the present invention is disclosed in US Application Ser. No. 09/850,662, filed May 7, 2001, the substance of which is incorporated herein by reference. Similarly, the drive mechanisms disclosed in U.S. applications Serial Nos. 10/114,780 filed April 3, 2002; and 10/128,018 filed April 22, 2002, both of which are herein incorporated

by reference, are also contemplated for use in conjunction with the present invention.

Another preferred embodiment toothbrush using a reciprocating drive shaft is illustrated in Fig. 12. Fig. 12 illustrates an electric toothbrush 800 comprising a toothbrush head 820, a body or handle 830, and an elongated neck 840 extending therebetween. The drive train, which includes various shafts and gears that transmit motion from a motor to an inner bristle holder 852 is similar to that described in US Patent No. 6,178,579, the substance of which is incorporated herein by reference. The handle 830 is hollow and includes a motor 802 and batteries (not shown) for powering the motor. A rechargeable power source can be substituted for the batteries. The head 820 has a longitudinal axis extending therethrough. The longitudinal axis extends in the same general longitudinal direction as a longitudinal axis of the shaft 860. The inner bristle holder 852 is disposed along the head 820, wherein the end 822 is at the distal-most point of the head 820. Although the inner bristle holder 852 is preferably oval in shape, other shapes can be utilized. Further, while the inner bristle holder 852 is disposed proximate the end 822 of the head 820, it will be appreciated that the holder 852 can be disposed away from the end 822 and other features, such as static bristles, can be disposed around at least a portion of the perimeter of the inner bristle holder 852. In this embodiment, the inner bristle holder 852 only reciprocates and does not oscillate, or perform any other rotational or oscillatory motion.

A first gear 804 is operatively connected to and powered by the motor 802. A second gear 806 is operatively connected to the first gear 804. The rotational axis of the second gear 806 is approximately normal to the rotational axis of the first gear 804 such that the teeth of the first gear 804 mesh with teeth of the second gear 806, thus causing second gear 806 to rotate as the first gear 804 rotates.

A first arm 808 is eccentrically and pivotably connected to the second gear 806 via a pin 810 or other fastening device. Due to the eccentric connection, the rotational motion of the second gear 806 is converted into a reciprocating motion of the first arm 808. A second arm 812 is pivotably

connected to the first arm 808 via a pin 814 or other fastening device. The shaft 860 is secured, such as by a press fit, to the second arm 812. The shaft 860 is housed at least partially within the neck 840. The shaft 860 is also engaged with a third arm 816. The third arm 816 is connected at its terminal end to the inner bristle holder 852 via a pin 818 or other fastening device. The terminal end of the third arm 816 is offset from the longitudinal axis of the shaft 860 so that it is pinned adjacent the outer periphery of the inner bristle holder 852. This offset arrangement converts the reciprocating motion of the third arm 816 into a reciprocating motion of the inner bristle holder 852, wherein the inner bristle holder 852 reciprocates about an axis approximately parallel to the longitudinal axis of the shaft 860.

While various brush head embodiments of the present invention have been illustrated for simplicity with tufts or groups of bristles that extend in a direction substantially perpendicular to the longitudinal axis of the head from which they extend, it is contemplated that the bristles might be arranged differently to complement or further enhance the static bristles or the motion of the movable bristles. Some or all of the bristles might extend in a direction which forms an acute angle with a top surface of a bristle holder, and may extend in a forward or rearward direction. In another embodiment, some of the bristles might extend outwardly away from the head, in another direction, again forming an acute angle with respect to the top surface of the bristle holder. Elastomeric tips or massaging bristles or bristles of varying height might also be used, such as described in US Patent Nos. Des. 330,286, and Des. 434,563, the substances of which are incorporated herein by reference. Other preferred bristle arrangements suitable for use include those arrangements described in whole or part in US Patent Nos. 6,006,394; 4,081,876; 5,046,213; 5,335,389; 5,392,483; 5,446,940; 4,894,880; and International Publication No. WO99/23910; the substances of which are incorporated herein by reference.

The electric toothbrushes of the present invention can be provided with any combination of bristle or elastomeric tip types, dimensions, combinations, angles and arrangements. Tufts of bristles may alternate in height. By "tuft", herein, is meant a set of one or more bristles fastened to the brush at a

common point. In one embodiment a plurality of tall tufts and a plurality of shorter tufts are disposed along the brush head. The difference in length between the tall tufts and the shorter tufts is between about 0.5 mm and about 2.5 mm in one embodiment and between about 1 mm and about 2 mm in other embodiments. The tall and short tufts of bristles can be provided with different characteristics. For example, the tall tufts of bristles may be relatively soft for gently cleaning and massaging gums of a user while shorter tufts of bristles may be somewhat firmer for interdental cleaning (or vice versa). This arrangement allows the longer (and typically softer) bristles to be pressed, bent and deflected against the gums of the user before the shorter (and typically firmer) bristles contact the teeth and gums of the user. Therefore, for example, soft bristles can be applied with more force while stiffer (and perhaps less comfortable) bristles are applied with less force.

In a particularly preferred embodiment, the present invention provides a bristle configuration in which the movable bristles, i.e. those supported by and secured to the movable bristle carrier, have a total bristle length that is less than the length of the static bristles that at least partially encircle or extend alongside the movable bristle carrier and bristles secured thereto. A further variation of this preferred bristle configuration features a movable bristle carrier that is slightly elevated above the outer surface of the head such that the distal tips of the movable bristles are approximately at the same height as the longer static bristles extending from the outer surface of the head. Generally, by utilizing movable bristles that have a relatively short length, the distance or stroke of the movable bristle carrier (when undergoing a reciprocating motion) is less than if longer bristles were used. A shorter stroke generally leads to decreased power requirements. This is beneficial since battery demands are then reduced, which may further promote manufacturability and commercialability of the resulting toothbrush. Moreover, by utilizing relatively short length bristles for the movable bristles, and longer bristles for the static bristles, a greater proportion of the brushing load is assumed by the static bristles. This generally further reduces power demands on the motor and drive mechanism of the toothbrush.

Bristle stiffness is also a parameter that has been found to affect brushing efficacy, power requirements of the preferred toothbrushes described

herein, and overall performance of the toothbrush. This parameter is particularly important to consider with regard to bristle length or height. For instance, for certain applications, it is preferable to utilize relatively stiff and short bristles on the movable brush head component in order to reduce the amount of travel by the brush head component.

The bristles, collectively, have a bristle stiffness which can be characterized numerically by the following equation:

$$\text{Bristle Stiffness} = \frac{D^2 E}{X^2} * \frac{N}{1 \times 10^6}$$

Where;

D=bristle diameter, in inches

E=modulus of elasticity of the bristle material when wet,

e.g. for nylon this is a constant, 460,000 psi

X=average bristle length across the head of the brush in inches

N=total number of bristles on brush head

The bristle stiffness for brushes of the present invention, as determined by the above equation, preferably ranges from about 0.2 to about 0.8. However, the present invention electric toothbrushes may utilize bristles having stiffness values outside of this preferred range.

The initial stiffness calculation,

$$\frac{D^2 E}{X^2}$$

for an individual bristle is a measure of the pressure produced by the minimum force required to deflect a single bristle according to *The Stiffness of Toothbrushes*, D.W. MacFarlane, Brit. Dent. Jour., October 5, 1945, which is hereby incorporated herein by reference. Bristle stiffness is obtained by multiplying this single bristle stiffness value by the total number of bristles on the brush head. The factor 1×10^6 used in the denominator of the foregoing equation

is an arbitrarily selected constant which reduces the overall bristle stiffness value to reasonably small numbers for ease of comparison. A detailed discussion of bristle stiffness is presented in U.S. Patent 5,511,275 herein incorporated by reference.

It can be seen from the foregoing noted equation that generally, stiffness may be increased by increasing the number of bristles. Applying this equation to an individual tuft of bristles suggests that the stiffness of an individual tuft of bristles may be tailored by increasing or decreasing the number of bristles within that tuft, i.e. the tuft density. This technique can be used to readily provide a brush head bristle configuration having unique and selectively tailored brushing characteristics.

Another aspect of the preferred embodiment toothbrushes described herein relates to bristle or tuft density, and particularly, in combination with bristle size and material. Bristles for use herein can be made of any of the materials well known in the art. Suitable bristle materials herein include polyester and nylon, such as Dupont Tynex⁷ 612 and Stylon⁷ 612 from STP. Suitable types of nylon include, but are not limited to Nylon 6/6, Nylon 10/10, and Nylon 12/12. The bristles are preferably of circular cross-section but can also be of other cross-sections including, but not limited to, rectangular, hexagonal and trilocular. Furthermore, the diameter and length of the bristles can vary within the usual dimensions known by a person skilled in the art. In preferred embodiments the bristles are of circular cross-section with a diameter of from 0.1 to 0.25 mm and length of from 7 to 15 mm, preferably 9 to 12 mm, with each tuft comprising from about 10 to about 50 bristles. The total number of bristles in the head portion of brushes of the present invention is preferably from about 1,200 to about 5,000, and even more preferably from about 1,600 to about 3,500. In such embodiments, each tuft is generally circular with a diameter of from about 1 to about 2 mm. It is also contemplated to utilize bristles and/or tufts of bristles having different diameters or spans together on a brush head.

Fastening of the bristle tufts to the brush head can be done using any of the methods known in the art, such as fusion, stapling and injection molding. Preferred processes herein are stapling and fusion. Each tuft has a

base and a free end, the free ends of the tufts forming the working surface which is used to clean the teeth. As used herein, the "base" of the tuft is that part of the tuft at which it meets the face of the brush head or movable bristle holder. It will be understood that a portion of the tuft extends below the base into the brush head or holder, for the purpose of anchoring the tuft into the head or holder. It is preferred for the head to comprise pre-molded tuft holes for the purpose of accommodating that portion of the tuft in this way. The tuft holes can be of any section including square and rectangular but are preferably circular. Their depth and diameter will be chosen by one ordinarily skilled in the art to suit the tufts to be inserted therein. Bristles inserted into a common tuft hole are considered to be fastened at a common point and to be part of the same tuft.

The length of the brush head is measured along the longitudinal axis of the toothbrush and generally from the distal end of the brush head to a location on the head just touching the tuft or row of tufts nearest the handle at the points of their base closest to the handle. Generally this brush head length is in the range from about 15 to about 35 mm, and preferably from about 20 to about 30 mm.

It is most preferred that the bristle or tuft density on the movable bristle holder is higher than the bristle density of the groups or regions of static bristles.

The present invention also provides several particularly preferred configurations of static bristles. The preferred configurations utilize a specific number of rows in designated regions of the brush head. These preferred configurations have been found to provide reduced load and wear on bristles that are disposed within the interior of the brush head, and particularly, the bristles that are supported on and by a movable bristle holder. Fig. 14 illustrates a preferred configuration for a group of static bristles disposed on a brush head 1020 of a toothbrush 1000. In this particular configuration, at least a single row of bristles encircle or substantially encircle the interior region of the brush head, i.e. the location in which the movable brush head is disposed. Specifically, the various preferred configurations for the static bristles 1060 may be conveniently described by referring to various regions of the brush head as sectors, and

describing the preferred arrangements of static bristles in each of those sectors. Fig. 14 illustrates a brush head 1020 having a centrally located sector C (within which a movable bristle carrier resides), that is surrounded by sectors D, E, F, and G. Sectors D and E are defined along the lateral and opposite sides of the brush head. Specifically, sector D is located between a first side 1031 of the brush head and sector C. Sector E is located between a second side 1033 of the brush head and sector C. Sector F is located between the first and second sides 1031 and 1033 of the brush head 1020, and a distal-most tip or end 1022 of the brush head 1020 and sector C. Sector G is defined between the first and second sides 1031 and 1033 of the brush head 1020, and the sector C and a neck 1040. Each sector in which static bristles may be located, may contain a certain number of rows of static bristles as follows. Before addressing the number of rows each sector preferably contains, it is instructive to define what is meant by a "row" of static bristles. A row of bristles is defined herein as an array or grouping of bristles that extends generally along a line or in a certain direction. Rows in sector D preferably extend in a direction that is generally parallel with the side 1031. Similarly, rows in sector E preferably extend in a direction that is generally parallel with the side 1033. Rows in sector F may extend in several fashions as follows. Rows in sector F may extend along an arc or other curved line generally following the curvature of sides 1031 and 1033 as the sides approach the distal end 1022 of the brush head 1020. Alternatively, rows in sector F may extend in a direction that is generally perpendicular to the longitudinal axis of the brush head 1020 and the neck 1040. This latter preferred configuration of rows is depicted in Fig. 14. Rows in sector G may extend along an arc or other curved line; such as extending along a line following the outer periphery of sector C. Alternatively, rows in sector G may extend in a direction that is generally perpendicular to the longitudinal axis of the brush head 1020 and the neck 1040. This latter preferred configuration of rows in sector G is depicted in Fig. 14, and such rows are preferably parallel to the rows in sector F.

The preferred number of rows of static bristles in sectors D, E, F, and G ranges from 0 to 4 or more. However, certain preferred combinations of rows are particularly preferred in accordance with the present invention. These

particularly preferred combinations are set forth in Table 1:

TABLE 1

Preferred Configurations for Rows of Static Bristles

Bristle Configuration Identifier	Number of Rows in Sector			
	D	E	F	G
a.	1	1	1-3	1
b.	1	1	1-3	2
c.	2	2	1-3	1
d.	2	2	1-3	2
e.	0	0	1-3	1
f.	0	0	1-3	2
g.	1	1	0	0
h.	2	2	0	0

Fig. 13, as previously noted, illustrates a preferred configuration for the static and movable bristles. In this configuration, rows of static bristles are located along opposing sides of the movable bristle holder. Within each row are groups or tufts of bristles. Preferably, the number of rows of bristles along each side of the bristle holder ranges from 1 to 6. Most preferably, the number of rows on each side of the movable bristle holder is either 1 or 2-6.

Fig. 15 illustrates one of the preferred static bristle configurations noted in Table 1 (bristle configuration identifier a). Specifically, Fig. 15 depicts a brush head 1120 of a toothbrush 1100 having a plurality of static bristles 1160 arranged in a predetermined number and combination of rows. It will be appreciated that although the rows depicted in Fig. 15 are shown as generally straight or linear, particularly in sectors F and G, the rows may follow the shape or curvature of the outer periphery of the brush head 1120 such as extending along a portion of the sides 1131 and 1133.

Within each sector of tufts, the distance between the bases of neighboring tufts is less than 1.3 mm, preferably from 0.6 to 1.2 mm, and more

preferably from 0.8 to 1.1 mm. Distances between the bases of the tufts, as referred to herein are measured from tuft edge to tuft edge along a straight line drawn between tuft centers along the bristle-bearing face. Distances between the free ends of the tufts, as referred to herein, are measured from tuft edge to tuft edge along a straight line drawn between tuft centers, parallel to the bristle-bearing surface, from the free end of the shorter tuft. Unless specifically defined otherwise, distances between tufts refer to distances between neighboring tufts. By "neighboring tuft" is meant the closest nearby tuft.

The distance between the bases of neighboring tufts in adjacent groups, that is, measured across the gap between groups, is in the range from about 1.3 mm to about 5 mm, preferably from about 1.5 to about 3.5 mm, more preferably from about 1.7 to about 3 mm. There can be some variation across individual pairs of tufts but all pairs, where the members of each pair are in different groups will be at least 1.3 mm apart at their bases.

By having a relatively large distance between tufts in adjacent groups, the groups of tufts are able to operate independently of each other. That is, tufts from one group do not substantially obstruct tufts from an adjacent group. This allows tufts on the margins of the groups, in particular, to penetrate better into the interproximal gaps and other crevices. Nevertheless, a relatively high, overall density of tufts on the brush head is maintained by the relatively small distance between tufts within groups. This, in particular, provides for good bristle coverage on individual tooth surfaces.

Additional aspects and parameters of bristles and tufts are described in U.S. Patent 6,314,605 herein incorporated by reference.

Another embodiment of the present invention is shown in Figs. 16 and 17, which utilizes one or more elastomeric tips. The head of an electric toothbrush as described herein is illustrated. The remaining portion of the brush, including the handle, motor, etc. is the same as described for any of the previously described embodiments. As shown in Fig. 16, a head 1216 includes a longitudinal axis L, a circular or moving portion or brush head 1220 and a static portion or region 1222. The head 1216 is located adjacent a first end 1228 of an elongated body portion. The static portion or portions 1222 is located on

opposite sides of the moving portion **1220**. The moving portion **1220** is located at the center of the brush head **1216**. The circular portion **1220** rotates, swivels, oscillates or reciprocates about an axis approximately normal to the longitudinal axis **L** of the brush head. The circular portion **1220** may rotate 360 degrees or partially rotate or oscillate or reciprocate in a back and forth manner.

The moving portion **1220** includes bristles **1224** and elastomeric tips **1225**. The static portion **1222** includes bristles **1226** and elastomeric tips **1227**. The elastomeric tips **1225**, **1227** massage the gums while the user simultaneously brushes his or her teeth. The elastomeric tips **1225**, **1227** can be made from a rubber, soft plastic or similar material. The elastomeric tips are preferably formed from an elastomeric material. The elastomeric tips **1225**, **1227** extend essentially perpendicularly from the head **1216** as measured along the longitudinal axis **L**. In the preferred embodiment the elastomeric tips **1225**, **1227** are located around the perimeter of the circular portion **1220** and the static portion **1222**, however it is to be understood that the elastomeric tips can be located anywhere among the bristles of the moving portion **1220** and the static portion **1222**. The length of the elastomeric tips **1225**, **1227** is approximately the same length as the bristles **1224**, **1226**. The elastomeric tips **1225**, **1227** may extend slightly above, slightly below or to the same height as the bristles **1224**, **1226**.

In a further preferred embodiment of the electric toothbrush having elastomeric tips as shown in Figs. **18** and **19**, a head **1386** includes a longitudinal axis **L**, a circular or moving portion or brush head **1306**, a static portion of brush head **1302**, a first end **1304** and a second end **1300**. The first end **1304** is located adjacent to the first end **1382** of the elongated body. The second end **1300** is located opposite the first end **1304**. The moving portion **1306** is preferably located at the second end **1300** of the brush head **1386**. The static portion **1302** is preferably located at the first end **1304** of the brush head **1386** adjacent to the moving portion **1306**. However, it is to be appreciated that the moving portion **1306** and the static portion **1302** can be arranged in different orientations. The moving portion **1306** can rotate, swivel, oscillate or reciprocate about an axis approximately normal to the longitudinal axis **L** of the brush head

1386.

The moving portion **1306** includes bristles **1310** and elastomeric tips **1311**. The static portion **1302** includes bristles **1312** and elastomeric tips **1313**. The elastomeric tips **1311**, **1313** massage the gums while the user brushes his or her teeth. The elastomeric tips **1311**, **1313** can be made from a rubber, soft plastic or similar material. The elastomeric tips are preferably formed from an elastomeric material. The elastomeric tips **1311**, **1313** extend essentially perpendicularly from the head **1386** as measured along the longitudinal axis **L**. In the preferred embodiment the elastomeric tips **1311**, **1313** are located around the perimeter of the moving portion **1306** and the static portion **1302**, however it is to be understood that the elastomeric tips can be located anywhere among the bristles of the moving portion **1306** and the static portion **1302**. The length of the elastomeric tips **1311**, **1313** is approximately the same length as the bristles **1310**, **1312**. The elastomeric tips **1311**, **1313** may extend slightly above, slightly below or to the same height as the bristles **1310**, **1312**.

The present invention is also based upon a unique design for a unitary body or housing for an electric toothbrush that incorporates an integral neck and brush head assembly. The one-piece body or housing greatly simplifies assembly of the toothbrush and reduces manufacturing costs associated with the brush. The present invention also provides a novel modular design for the brush head that enables a wide array of bristle sets to be used in conjunction with the toothbrush.

Referring to Fig. 20, a preferred embodiment toothbrush **1400** is illustrated. The toothbrush **1400** comprises a body **1480**, a head **1420** and an intermediate portion or neck **1440** extending between, and integrally formed with, the body **1480** and the head **1420**. Movably retained on the head **1420** are a collection of bristles **1450** which are supported on a movable bristle carrier described in greater detail herein. Also disposed on the brush head **1420** are a collection of static bristles **1460**. Preferably, the static bristles **1460** extend around the periphery of the head **1420**. The static bristles **1460** are supported and retained on either the head **1420**, or a distally located brush head tip, described and illustrated in greater detail herein.

Fig. 21 is a partial exploded view of the preferred embodiment toothbrush 1400 shown in Fig. 20. Fig. 21 illustrates a preferred assembly and configuration of components utilized in the toothbrush 1400. Specifically, the toothbrush 1400 further comprises an end cap or base 1482 which snaps on or is otherwise releasably secured to the end of the body 1480. The end cap or base 1482 may be provided in a variety of different shapes and configurations. The body 1480 also includes a region adapted for retaining a switch or other actuator assembly 1486 for controlling operation of a motor, battery, and drive train or mechanism (not shown) preferably disposed in the body 1480 of the toothbrush 1400. This switch region is illustrated in Fig. 21 as region 1484. The switch or actuator 1486 is received and retained at region 1484. The body 1480 provides a hollow interior cavity or chamber in which is disposed the motor and drive mechanism. Upon operation, the drive mechanism preferably provides a drive shaft that reciprocates in a direction generally parallel to the longitudinal axis of the toothbrush 1400. Referring to the brush head 1420 of the toothbrush 1400 in Fig. 21, it will be noted that the brush head is shown without any bristles 1450, 1460 (as shown in Fig. 20). This is to more clearly illustrate assembly of the toothbrush 1400. It can be seen that one face of the brush head 1420 is configured so as to include a generally flat surface 1422 which defines a plurality of mounting locations or apertures 1424 for the static bristles 1460. Preferably this flat region 1422 and its plurality of apertures 1424 extend about the outer periphery of the brush head 1420 as shown in Fig. 21. Most preferably, this flat region 22 extends in a U-shape as shown in Fig. 21. Defined along the interior or medial region of the brush head 1420 is a receiving surface 1425 generally extending between two inwardly facing surfaces 1426 and 1427. The channel defined by surfaces 1425, 1426, and 1427 is generally sized so as to receive components 1452 and 1430 as follows.

The preferred embodiment toothbrush 1400 also comprises a movable bristle carrier 1452 which, upon installation and assembly in the brush, is retained along the brush head 1420 and preferably within the channel defined by surfaces 1425, 1426, and 1427. Movable bristle carrier 1452 defines a plurality of apertures 1454 as shown in Fig. 21. The bristle carrier 1452 also

defines an aperture **1453** that is sized and adapted to receive a pin or other member for engagement with the drive mechanism (not shown) disposed in the body **1480** and neck **1440** of the toothbrush **1400**. The present invention includes other engagements between the movable bristle carrier **1452** and a drive shaft, such as but not limited to, a snap type engagement.

The toothbrush **1400** further comprises a brush head tip **1430** which, after assembly of the movable bristle carrier **1452** on the head **1420**, may also be received and secured along the head **1420**. The stationary brush tip **1430** also defines a plurality of apertures **1434** adapted for retaining a plurality of static bristles **1460** as shown in Fig. 20.

Figs. 22 to 24 illustrate a sequence of assembly of the movable bristle carrier **1452** and the brush head tip **1430** with the brush head **1420** of the preferred embodiment toothbrush **1400**. Specifically, Fig. 22 illustrates the brush head **1420** and neck **1440** of the preferred embodiment toothbrush **1400**. The brush head **1420** is oriented to receive the movable bristle carrier **1452**. Specifically, the bristle carrier **1452** is preferably slidingly engaged within the channel defined by the surfaces **1425**, **1426**, and **1427** in the brush head **1420**. The brush head **1420** includes a passage **1428** defined within a portion of the head **1420** and the neck **1440**. The passage **1428** provides access between the brush head **1420** and the interior of the body **1480** and neck **1440**. This passage **1428** is adapted to enclose and retain a shaft or other component of a drive mechanism. The distal end of the drive shaft (not shown) is preferably secured to the movable bristle carrier **1452** such as by attachment at aperture **1453** of the carrier **1452**. Accordingly, the bristle carrier **1452** is oriented within the channel defined on the head **1420** such that the aperture **1453** is proximate the passage **1428**. As previously noted, a snap-fit connection may be utilized between the bristle carrier **1452** and the distal end of the drive shaft.

Fig. 23 illustrates the movable bristle carrier **1452** slidingly engaged within the head **1420** of the preferred embodiment brush **1400**. After engagement of the movable bristle carrier **1452** in the head **1420**, the brush head tip **1430** may be secured along the distal end of the brush head **1420**. The brush head tip **1430** preferably is also slidingly engaged within the head **1420**, and

specifically within the channel defined by the surfaces **1425**, **1426**, and **1427**. One or more retaining grooves or channels are preferably defined along the outer surfaces of either the tip **1430** or the channel defined by the surfaces **1425**, **1426**, and **1427** within which outwardly extending projections defined on an opposing surface, reside to secure the tip **1430** within the head **1420**. A wide array of channel configurations may be utilized in accordance with the present invention. Although a channel and corresponding channel components are used to assist in retaining the movable bristle carrier to the brush head, it is contemplated that other retaining assemblies or configurations may be utilized. As previously noted, the present invention toothbrushes are not limited to a particular motion or direction of motion for the movable bristle carrier.

Fig. **24** illustrates final assembly of the tip **1430** along the distal end of the brush head **1420**. It will be appreciated that the various components noted in these figures, would include the bristles **1450**, **1460**. The bristles have been omitted from these figures to more clearly illustrate assembly of the primary components of the toothbrush **1400** and specifically along the brush head **1420**. It will be further appreciated that the brush head tip may be formed in a variety of shapes and configurations. It may in some instances, be preferred to provide a brush head tip having an arcuate or U shape. Or, the tip may be formed so as to constitute a relatively large portion of the brush head.

It will be understood that the present invention includes assemblies featuring a releasably removable brush head tip, similar to tip **1430** shown in the noted figures. A removable tip enables a user to selectively tailor and customize a brush as desired. For example, a tip containing one or more elastomeric tips, massaging members, various bristle configurations, or other dental tools could be attached to the toothbrush of the present invention. For instance, tips that are specifically designed for applying whitening agents to the teeth may be used. Other examples include tips designed for tartar control or removal, and tips designed for gum massage or other therapeutic treatment. It is also contemplated that elastomeric tips or "cushioning" tips may be provided and/or used with the present invention toothbrushes. Such elastomer tips are formed entirely or partially from thermoplastic elastomers. Elastomeric tips are

particularly preferred for incorporation in toothbrushes that utilize one or more other regions or components that are formed from elastomers. For example, the present invention includes toothbrushes as described herein with elastomeric tips and which employ one or more elastomers in gripping regions along the handle, or as "bumpers" or cushioning regions along the brush head. Such elastomers may be co-injected when forming the brush, or may be coated thereon.

The releasable aspect of the brush head tip may be provided by incorporating a release member along the underside of the brush head that, when pressed or otherwise engaged, allows the brush head tip to be removed and another tip positioned in its place. It is further envisioned that the releasable aspect could be achieved by use of a tool or other component to selectively release the tip from the brush head. Such a tool could be sold or otherwise commercialized with the toothbrush. Alternatively or in addition, such a tool could be sold or otherwise commercialized with one or more tips that are sold as a kit for use with the present invention toothbrushes. More specifically, such kits might include one or more of the following and thus incorporate a combination of any of the following components: (i) one or more replaceable brush head tip(s), (ii) one or more toothbrushes, (iii) a package or other housing for storing all the components, (iv) one or more tools that might be useful when replacing or substituting or otherwise changing tips, and (v) one or more dentifrice or other compositions for use with the tip(s) and toothbrush. It is further envisioned that such kits may include batteries for use with the toothbrush, bases or other "stands" for retaining the toothbrush when not in use, replaceable handle components that are used to change the appearance of the toothbrush, and decorative stickers or other types of labels that may be placed on the toothbrush, its stand, and/or the kit housing.

A wide array of bristle configurations may be utilized in conjunction with the toothbrushes of the present invention, and particularly those embodiments that utilize a removable or separately formed brush head tip. For instance, static bristles having a height or length that is equal to that of the movable bristles may be utilized. Any of the previously noted configurations of the static bristles and movable bristles shown in the referenced figures, described

herein, or noted in Table 1 may be utilized. Specifically, Figs. 25 and 26 illustrate the brush head **1420** and the neck **1440** of the preferred embodiment brush **1400** with a collection of static bristles **1460** disposed on a tip **1430** at the distal end of the brush head **1420** and a collection of movable bristles **1450** disposed on a movable bristle carrier **1452** (the carrier **1452** shown in dashed lines). Preferably, the height of the movable bristles **1450** along the toothbrush head **1420**, designated in Fig. 25 as dimension **C**, ranges from about 3 mm to about 14 mm, and preferably from about 7 mm to about 11 mm. Generally, bristle height is the distance of a bristle as measured from an outwardly directed surface, i.e. typically the surface of its base or mounting component, to the end or tip of the bristle. The noted outwardly directed surface of a bristle mounting component is generally referred to herein as a brush-facing surface. Although not shown in Fig. 25, it will be appreciated that a plurality of static bristles, supported and retained directly on the brush head **1420**, are preferably disposed around the movable bristles **1450**. It will be appreciated that such static bristles are not shown in these figures (nor in Figs. 27-30) for purposes of clarity. The preferred height of the static bristles (those disposed around the movable bristles **1450** and those disposed on the tip **1430**) also ranges from about 3 mm to about 14 mm, and preferably from about 7 mm to about 11 mm.

It is also contemplated to provide static bristles having a varying length, and particularly, arranged in a manner so as to provide an inclined brushing surface. This is shown in Figs. 27 to 33. The term "brushing surface" as used herein refers to the distal ends of bristles or elastomeric tips that contact a user's teeth or gums during brushing.

Specifically, Figs. 27 and 28 illustrate a toothbrush head **1520** and a neck **1540** of another preferred embodiment toothbrush **1500** according to the present invention. The brush head **1520** includes a movable bristle carrier **1552** having a plurality of movable bristles **1550** (the carrier **1552** shown in dashed lines) supported or retained therein. The brush head **1520** also includes a tip **1530** having a collection of static or stationary bristles **1560** supported or retained thereon. It will be appreciated that a plurality of stationary bristles **1560** preferably surround, or at least partially so, the movable bristles **1550**. For

clarity, that portion of bristles supported directly on the brush head 1520 is not shown in Fig. 27. The tip 1530 preferably includes stationary bristles 1560 having different lengths and arranged so as to provide an inclined brushing surface. When providing an inclined brushing surface, such as specifically shown in Fig. 27, the angle A, which is the angle of the inclined surface with respect to the longitudinal axis of the neck 1540 and head 1520, may range from about 5 degrees to about 85 degrees, and preferably from about 20 degrees to about 70 degrees. Most preferably, the longer bristles are disposed adjacent the distal end of the head 1520. The height of the movable bristles 1550, designated in Fig. 27 as dimension D, ranges from about 3 mm to about 14 mm, and preferably from about 7 mm to about 11 mm. The height of the static bristles 1560 ranges from about 3 mm to about 18 mm, and preferably from about 7 mm to about 11 mm. The maximum height of the static bristles 1560 and particularly those disposed at the distal end of the head 1520 is about 18 mm. That dimension is shown as dimension E in Fig. 27.

Figs. 29 and 30 illustrate yet another preferred configuration for bristle configurations. These figures illustrate a preferred embodiment toothbrush 1600 having a neck 1640, a toothbrush head 1620, a movable bristle carrier 1652 (shown in dashed lines) having movable bristles 1650, a toothbrush head tip 1630, and a collection of static bristles 1660 located on the end tip 1630 disposed at the end of the toothbrush head 1620. In this embodiment, the collection of static bristles 1660 on the tip 1630 are arranged so as to provide an inclined brushing surface. The height of the movable bristles 1650, designated in Fig. 29 as dimension F, ranges from about 3 mm to about 14 mm, and preferably from about 7 mm to about 11 mm. The height of the static bristles 1660, ranges from about 3 mm to about 18 mm, and preferably from about 7 mm to about 11 mm. The maximum height of the static bristles 1660 and particularly those disposed at the distal end of the head 1620 is about 18 mm. That dimension is shown as dimension G in Fig. 29. The embodiment illustrated in Figs. 29 and 30 differs from that depicted in Figs. 27 and 28 primarily in that the static bristles 1660 disposed on the brush head tip 1630 do not linearly vary in height from one end of the tip 230 to the other, as do the bristles 150 in Fig. 27. Restated, the

resulting surface defined by the distal ends of the bristles **150** in Fig. **27** is generally straight, whereas the resulting surface defined by the distal ends of the bristles **1660** in Fig. **29** is generally arcuate.

It is also contemplated to utilize various bristle configurations at the toothbrush head tip which provide varying inclinations and changing bristle height across the width of the brush head as shown in Figs. **31** to **33**. Specifically, Fig. **31** illustrates a preferred embodiment toothbrush **1700** having a brush head **1720** and a plurality of static bristles **1760**. The bristles **1760** provide an inclined brushing surface that forms an angled valley, when viewed along a line in the same direction as the longitudinal axis of the brush head **1720** and neck (not shown in Fig. **31**). Preferably, each side of the valley formed by the distal ends of the bristles **1760** is symmetrical and extends so as to form an angle **B** with respect to a vertical line perpendicular to a longitudinal axis of the brush head **1720** and neck (not shown). Angle **B** may range from about 10° to about 80°, and preferably from about 30° to about 60°.

Fig. **32** illustrates another preferred embodiment toothbrush **1800** having a brush head **1820** with a plurality of static bristles **1860** extending therefrom. The contoured or arcuate brushing surface provided by the distal ends of the bristles **1860** may be in the form of a concave region or surface as shown in Fig. **32**.

Fig. **33** illustrates another preferred embodiment toothbrush **1900** having a brush head **1920** and a plurality of static bristles **1960** extending therefrom. The bristles **1960** may provide an irregular brushing surface as shown.

Fig. **34** illustrates a portion of another preferred embodiment toothbrush **2000**. This toothbrush comprises a brush head **2020**, a neck or intermediate portion **2040**, a movable bristle carrier **2052** (shown in dashed lines), a brush head tip **2030** (shown in dashed lines), and a plurality of bristles **2050** and a plurality of elastomeric tips **2060**. The bristles **2050** may include movable bristles, static bristles, or both, as described herein. The elastomeric tips **2060** massage the gums while the user simultaneously brushes his or her teeth. The elastomeric tips can be made from a rubber, soft plastic or similar

material. The elastomeric tips are preferably formed from an elastomeric material. The elastomeric tips extend essentially perpendicularly from the toothbrush head **2020** as measured along the longitudinal axis of the toothbrush **600**. In the preferred embodiment toothbrush **2000**, the elastomeric tips **2060** are located proximate the distal end of the toothbrush head **2020**, and most preferably along the brush head tip **2030** as described herein. However, it is to be understood that the elastomeric tips can be located anywhere among the moving and static bristles. The height of the elastomeric tips **2060** is approximately the same height as the bristles **2050**. The elastomeric tips **2060** may extend slightly above, slightly below or to the same height as the bristles **2050**.

Fig. 35 illustrates another preferred embodiment toothbrush **2100** comprising a toothbrush head **2120**, a movable bristle carrier **2152** (shown in dashed lines), and a neck or intermediate portion **2140**. The toothbrush **700** includes a plurality of bristles **2150** and a second set of bristles **2160** disposed on a brush head tip **2130** (shown partially in dashed lines). In this preferred embodiment, the bristles **2150** are arranged in groups of tufts wherein each tuft contains bristles of various lengths or heights. The bristles of varying height are arranged within each tuft such that the distal ends of the bristles form an inclined surface with respect to the generally flat surface or brush-facing surface of the brush head **2120**. Preferably, this inclined surface forms an angle **H** with respect to the flat face of the brush head **2120**. Angle **H** is in the range of from about 10° to about 90° and preferably from about 20° to about 45°.

The second set of bristles **2160** disposed on the brush head tip **2130** are preferably also arranged in groups or tufts. The preferred height of bristles **2160** is approximately equal to the maximum bristle height of the bristles **2150**. Fig. 35 illustrates a particularly preferred feature of the present invention toothbrushes, and relating to the configuration of the brush head tip **2130**. The brush head tip **2130** is provided with a region **2132** having a relatively large thickness such that its flat, brush-facing surface generally extends above the brush-facing surface of the carrier **2152**. This difference in height between the brush-facing surfaces of the regions of bristles **2150** and bristles **2160** is

illustrated in Fig. 35 as dimension **P**. Preferably, **P** is from about 1 to about 5 mm.

Fig. 36 is another illustration of a preferred embodiment toothbrush **2200** having a head **2220**, a movable bristle carrier **2252** (shown in dashed lines), and a neck **2240**. Disposed on the brush head **2220** are a plurality of upwardly extending bristles **2250**. The toothbrush **2200** also includes a brush head tip **2230** (shown partially in dashed lines) disposed at the distal end of the brush and having a region **2232** that extends above the flat, brush-facing surface of the brush head **2220** and the carrier **2252**. The plurality of bristles **2250** are preferably configured such that their outermost tips, when viewed in planar fashion as shown in Fig. 36, define an arcuate brushing surface, preferably having a common radius as shown in Fig. 36, designated as **I**. The brush head tip **2230** includes the raised region **2232** that is preferably formed to define a sloping surface with respect to the flat, brush-facing surface of the brush head **2220** and the carrier **2252**. This angle of slope is shown in Fig. 36 as angle **N**. Angle **N** may range from about 10° to about 80°, with 15° to 45° being preferred. The height of the bristles **2260** may be greater or lesser than any of the heights of the bristles **2250**. The bristle configuration depicted in Fig. 36 is exemplary.

Fig. 37 illustrates another preferred embodiment toothbrush **2300** according to the present invention. Toothbrush **2300** comprises a brush head **2320**, a movable bristle carrier **2352** (shown in dashed lines), and a neck **2340**. The toothbrush **2300** includes a plurality of bristles **2350** and another set of bristles **2360** disposed on a brush head tip **2330** (partially shown in dashed lines). The brush head tip includes a raised region **2332** extending above the brush-facing surface of the brush head **2320** and carrier **2352**. The outermost surface of the raised region **2332** of the brush head tip **2330** is preferably sloped at an angle **K** as shown in Fig. 37. Angle **K** may range from about 10° to about 80°, with 15° to 45° being preferred. The bristles **2350** are also particularly configured such that their outermost or distal ends define a concave brushing surface, preferably having a common radius **J** as shown in Fig. 37. The height of the bristles **2360** may be greater or lesser than any of the heights of the bristles **2350**. However, it may in some applications be preferred to arrange the bristles

2360 such that their distal ends generally extend within a plane that is parallel with the sloping surface of the raised region **2332** of the brush head tip **2330**. This angle **M** preferably corresponds to angle **K**, and so may range from about 108 to about 808 with 158 to 458 being preferred.

Fig. **38** is another preferred embodiment toothbrush **2400** having a brush head **2420**, a movable bristle carrier **2452** (shown in dashed lines), a brush head tip **2430** (also shown in dashed lines), and a neck **2440**. The toothbrush **2400** includes a plurality of bristles **2450**, a second set of bristles **2460** disposed on the brush head tip **2430**, and a plurality of elastomeric tips **2454**. The arrangement, height, and configuration of the bristles **2450**, **2460**, and elastomeric tips **2454** may be as described herein with regard to any of the other preferred embodiments.

Fig. **39** illustrates another preferred embodiment toothbrush **2500** having a brush head **2520**, a movable bristle carrier **2552** (shown in dashed lines), and a neck **2540**. The toothbrush **2500** includes a plurality of bristles **2550** and a plurality of elastomeric tips **2554** preferably disposed at opposing angles from each other. That is, the elastomeric tips **2554** preferably extend at an angle **O** as shown in Fig. **39**. The collection of bristles **2550** preferably extend in the opposite direction but at a similar angle. The toothbrush **2500** also includes a plurality of bristles **2560** extending from a brush head tip **2530** (shown partially in dashed lines). The brush head tip may also include a region **2532** extending above the flat, brush-facing surface of the brush head **2520**. This raised region **2532** may further provide an arcuate outer surface that may be defined by a common radius such as radius **Q** shown in Fig. **39**. The arrangement, height, and configuration of the bristles **2550**, **2560** and elastomeric tips **2554** may be as described herein with regard to any of the other preferred embodiments.

Fig. **40** illustrates yet another preferred embodiment toothbrush **2600** having a brush head **2620**, a movable bristle carrier **2652** (shown in dashed lines), and a neck **2640**. The toothbrush **2600** includes a brush head tip **2630** (also shown in dashed lines) having a plurality of bristles **2660** extending therefrom. Another set of bristles **2650** are provided on the brush head **2620**, and specifically on the movable bristle carrier **2652**. In this preferred

embodiment, the height of the bristles **2660** is significantly greater than the height of the bristles **2650**. As previously described herein, the bristles **2650**, **2660** may be arranged in groups or tufts wherein the bristles within a particular tuft may have different lengths.

Fig. **41** illustrates yet another preferred embodiment toothbrush **2700** having a brush head **2720**, a neck **2740**, a movable bristle carrier **2752** (shown partially in dashed lines), a plurality of bristles **2750** extending from the bristle carrier **2752**, and another set of bristles **2760** extending from a brush head tip **2730** (shown in dashed lines). In this preferred embodiment, the bristle carrier **2752** has a relatively large thickness such that its flat, brush-facing surface is generally elevated above or disposed closer to the user during brushing, than the brush-facing surface of the brush head tip **2730** and other portions of the brush head **2720**. The elevated portion of the bristle carrier **2752** that extends past the adjacent regions of the brush head **2720** and the brush head tip **2730** is designated in Fig. **41** as **2745**. For bristle configurations in which the distal ends or brushing surfaces of the bristles **2750** and **2760** generally extend along a common plane, the resulting shorter length of bristles **2750** imparts an increased stiffness to those bristles. The extent of elevation of the region **2745** of increased thickness is shown in Fig. **41** as dimension **R**. **R** may range from about 1 mm to about 5 mm.

Fig. **42** illustrates another preferred embodiment toothbrush **2800** having a brush head **2820** and a neck **2840**. A plurality of bristles **2850** are provided on the brush head and extend from a bristle holder **2852** (partially shown in dashed lines) which is preferably movable with respect to the head **2820**. The toothbrush **2800** also comprises another plurality of bristles **2860** that extend from a brush head tip **2830** (partially shown in dashed lines). In this preferred embodiment, the brush-facing surface of the bristle carrier **2852** is preferably sloping, more preferably arcuate, and most preferably convex as shown in Fig. **42**. In the event this surface is convex, it is further defined by a radius **S** as shown in Fig. **42**. The upwardly directed brush-facing surface of the bristle carrier **2852** is also preferably elevated above the relatively flat, brush-facing surface of the brush head **2820**, preferably by dimension **T** shown in Fig.

42. Dimension T may range from about 1 mm to about 5 mm. The elevated portion of the bristle carrier **2852** that extends past the adjacent regions of the brush head **2820** is designated as **2845**. The brush-facing surface of the brush head tip **2830** is preferably arcuate and more preferably concave. The elevated portion of the bristle carrier **2830** that extends past the adjacent regions of the brush head **2820** is designated as **2832**. The arrangement, height, and configuration of the bristles **2850** and **2860** may be as described herein with regard to any of the other preferred embodiments.

Fig. **43** illustrates another preferred embodiment toothbrush **2900** having a brush head **2920**, a movable bristle carrier **2952** (shown partially by dashed lines), a brush head tip **2930** (shown by dashed lines), and a neck **2940**. A collection of bristles **2950** extend from the bristle carrier **2952**. And, another collection of bristles **2960** extend from the brush head tip **2930**. The bristles **2950** are preferably disposed and retained on the movable bristle carrier **2952**. The bristle carrier **2952** provides an upwardly directed, brush-facing surface which is depicted in Fig. **43** as concave. Preferably, this concave surface is defined by a common radius **U**. The elevated portion of the bristle carrier **2952** that extends past the adjacent regions of the brush head **2920** is shown as region **2945**. The arrangement, height, and configuration of the bristles **2950** and **2960** may be as described herein with regard to any of the other preferred embodiments.

Fig. **44** illustrates yet another preferred embodiment toothbrush **3000** according to the present invention. The toothbrush **3000** comprises a brush head **3020** and a neck **3040**. The toothbrush **3000** includes a plurality of bristles **3050** extending from a bristle carrier **3052** (shown partially in dashed lines) that is movably disposed on the brush head **3020**. And, the toothbrush **3000** includes another set of bristles **3060** extending from a brush head tip **3030** (shown partially in dashed lines). The outermost surface of the bristle carrier **3052** may be provided such that it has one or more sloping surfaces defined along a raised region **3045** as shown in Fig. **44**. These slopes may be carried through such that the distal-most ends of the bristles **3050** mirror this same slope or, another or different slope. Similarly, the outermost end of the bristles **3060** may also reflect the sloping surface of a raised region **3032** of the brush head end **3030**.

Preferably, the bristle carrier **3052** provides at least a region having a sloping brush-facing surface. That slope preferably extends along an angle **V** as shown in Fig. **44**. Angle **V** preferably is from about 108 to about 608, and more preferably from about 208 to about 308. Similarly, the brush head tip **3030** preferably provides a sloping brush-facing surface that extends along an angle **W**. Angle **W** preferably ranges from about 108 to about 458.

Fig. **45** is another preferred embodiment toothbrush **3100** having a brush head **3120** and a neck **3140**. The toothbrush **3100** includes a plurality of elastomeric tips **3162** extending from a brush head tip **3130** (shown partially in dashed lines). The toothbrush **3100** also comprises a plurality of bristles **3150** extending from a movable bristle carrier **3152**. The bristle carrier **3152** contains a region **3145** that is raised relative to the adjacent regions of the brush head **3120**. Similarly, the brush head tip **3130** contains a region **3132** that is raised relative to the adjacent regions of the brush head **3120**. Either or both of the outwardly directed, brush-facing surfaces of the bristle carrier **3152** and the brush head tip **3130**, may be flat, sloping, arcuate, convex or concave. Furthermore, the arrangement, height, and configuration of the bristles **3150** and elastomeric tips **3162** may be as described herein with regard to any of the other preferred embodiments.

Another preferred bristle configuration is similar to the configurations shown in Figs. **36** and **45**, i.e. having an interior group of bristles that extend "above" or have a greater height than adjacent bristles, however features a stepped or plateau configuration. In this configuration, the change in bristle height is not gradual or varying as shown in Figs. **36** and **45**, but instead is stepped. That is, the change in height from shorter bristles disposed around the taller medially disposed bristles is rather abrupt. The difference in height between these two groups of bristles is about 0.5 mm to about 3 mm, and more preferably from about 0.75 mm to about 1.5 mm.

Referring to the various bristle carriers illustrated and described herein, it can be seen that the profile or configuration of the outwardly facing surface of the carrier, generally referred to herein as a brush-facing surface, may be in a variety of forms and shapes. One particularly preferred shape is a

concave shape (when viewing the bristle carrier from its side, and its side that generally extends along the same direction as the longitudinal axis of the toothbrush). A concave shape promotes the retention of dentifrice or polishing material that may be used during brushing. Likewise, a convex surface promotes the dissipation of dentifrice in the region of the bristles along the brush head. Most preferably, bristle carriers in accordance with the present invention utilize a non-flat brush-facing surface.

Another aspect of interest in the design of a brush head is the selection, placement, and configuration of bristles along the bristle carrier, brush head tip, and brush head. Generally, the stiffness of a bristle or tuft of bristles increases as the length of the bristle(s) decreases. Thus, changes in bristle stiffness may be achieved by altering the length of the subject bristles. This characteristic is important to consider when providing a bristle carrier having a brush-facing surface that is non-planar. It will be appreciated that bristle stiffness will vary at different locations along the bristle carrier since the length or height of the bristles extending therefrom varies. Alternatively, the stiffness of bristles having equal heights will be generally the same. The present invention includes a wide array of different combinations of bristle carrier shapes and configurations; and bristle length, materials, and configuration. Many of these preferred configurations have been exemplified in the referenced figures. Additionally, in some embodiments, it is preferred to utilize diameters of bristles and/or diameters of tufts of bristles on the movable bristle carrier that are larger than corresponding diameters of bristles or tufts of bristles that are disposed on the brush head tip. In yet other embodiments, it may be desirable to utilize diameters of bristles/tufts on the carrier that are smaller than corresponding bristles/tufts on the tip.

Figs. 46 and 47 illustrate in greater detail a preferred brush head 3220 of a preferred embodiment toothbrush 3200 according to the present invention. The toothbrush 3200 comprises a brush head 3220 and a neck 3240 integrally formed with and extending therefrom. The toothbrush 3200 further comprises a movable bristle carrier 3245 defining a plurality of holes or apertures 3254 adapted for receiving and retaining bristles or bristle tufts (not shown). The bristle carrier 3245 provides an outwardly directed brush-facing surface 3252.

Defined along an oppositely directed face is an under-surface **3253**. A receiving aperture **3254** is also defined along the under-surface **3253** and is sized and adapted to receive and engage a distal end **3206** of a movable drive shaft **3205**. As will be appreciated, the drive shaft **3205** reciprocates within the neck **3240** and imparts a similar reciprocating type motion to the bristle carrier **3245**. The toothbrush **3200** also comprises a brush head tip **3230** defining an outwardly directed brush-face surface **3232** and one or more apertures **3234** adapted to receive and retain bristles or bristle tufts (not shown). The brush head **3220** may also define one or more apertures located along the brushing face of the head **3220**, such as apertures **3224** defined in the region **3222** of the head **3220**.

Although the assembly shown in Fig. 47 for engaging the bristle carrier **3245** with the shaft **3205** is generally preferred, i.e. use of a notched distal end **3206** that is received in aperture **3254**, other assemblies for engaging a movable bristle carrier with a drive shaft may be utilized. For example, the present invention includes engagement assemblies using pins or other fasteners that affix the drive shaft to the carrier. Alternatively, other assemblies may be used such as snap-fit connections, releasable engagement assemblies, and nonreleasable assemblies. The materials employed for the components of the engagement assemblies can be polymeric, metal, or any other material having suitable strength and durability properties.

Fig. 48 is a partial exploded view of a preferred embodiment toothbrush **3300** according to the present invention. The preferred embodiment toothbrush **3300** comprises a body or housing **3312** and an end cap **3320**. The body **3312** is essentially a one-piece body having a major portion including a neck **3316** and an end **3318**, and a brush head **3314** extending from the neck **3316**. Preferably, the brush head **3314**, neck **3316**, and body **3312** are generally continuous and integrally formed with one another. The body **3312** and portions of the neck **3316** and head **3314**, define a hollow interior region, which house a drive mechanism. The major portion of the body **3312** also defines a recessed region or one or more apertures along its outer surface which receives an electrical switch (not shown) for operating the drive mechanism of the electric toothbrush described in greater detail herein. A protective cover **3313** preferably

fits within this recessed region. The end cap **3320** includes a closed end **3322** and an opposite open end **3324**. The open end **3324** is sized to engage and generally seal the end **3318** of the housing **3312**. An O-ring or other sealing member **3319** may be used at the interface of the ends **3318** and **3324** of the housing components.

The preferred embodiment toothbrush further comprises a drive motor **3350** having a drive shaft **3352**. The motor **3350** is a DC motor similar to motors known to those skilled in the art and includes various switching circuits and a battery or other power source (not shown). These components are housed and retained within the hollow interior region defined in the body **3312** and optionally within the end cap **3320**. A drive gear **3354** is engaged to the drive shaft **3352**. A lower motor mount **3330** is provided. An upper motor mount **3340** is also provided which, together with the lower motor mount **3330**, generally cradle, retain, and secure the motor **3350** within the interior of the housing **3312** and cap **3320**. The lower motor mount **3330** includes inner and outer drive shaft supports **3332** and **3334**, respectively. The lower motor mount **3330** also includes a base or aperture **3336** for receiving a mount or axle **3358** for a drive gear described in greater detail herein. The upper motor mount **3340** includes an inner drive shaft support **3342** and a drive shaft housing **3344** which preferably engages the inner mount **3342** and optionally the outer mount **3334** of the lower motor mount **3330**. The upper motor mount **3340** additionally includes a plurality of engagement legs **3346** that preferably engage the lower motor mount **3330** for retaining motor **3350** disposed between the two assemblies. It will be appreciated that instead of utilizing an upper and lower motor mount, a single one-piece mount or retaining structure could be employed.

The drive gear **3354** is engaged with a crown gear **3356**. Crown gear **3356** is rotatably supported at its center **3357** by the axle or pivot member **3358**. The crown gear **3356** includes an offset engagement member **3355** to which is attached a pinion end **3362** of a drive shaft **3360**. The drive shaft **3360** includes the noted pinion end **3362** that includes a receiving aperture or other engagement member for engagement with the offset member **3355**. The drive shaft **3360** further includes a distal end **3364** which is used to engage and thus

drive a movable bristle holder described in greater detail herein. The drive shaft **3360** extends within the interior hollow cavity of the housing **3312** and preferably through at least a portion of the neck **3316**. The distal end **3364** of the drive shaft **3360** is engaged with a bristle carrier **3370**, described below. The end **3364** is accessible through an aperture in the brush head **3314**.

The preferred embodiment toothbrush **3300** further includes a movable bristle carrier **3370** which, upon assembly in the preferred embodiment toothbrush **3300**, reciprocates along the brush head **3314**. Preferably, the movable bristle carrier **3370** reciprocates within a channel **3311** defined along the brush head **3314**, and most preferably in a direction parallel with the longitudinal axis of the toothbrush **3300**. Disposed along the underside of the bristle carrier **3370** is a ridged member **3372**. This ridged member **3372** is configured to move within, yet be retained by, the channel **3311**. The bristle carrier **3370** defines a plurality of apertures **3374** within which are disposed a plurality of bristles or bristle tufts (not shown). The bristle holder **3370** includes a first end **3375** which, upon assembly with the brush head **3314**, is preferably disposed adjacent a region or edge **3315** defined between the neck **3316** and the brush head **3314** of the body or housing **3312**. The opposite end of the movable bristle carrier **3370** is end **3376** and is preferably curvilinear as shown in Fig. 48.

The preferred embodiment toothbrush **3300** further comprises a stationary bristle carrier tip **3380** which defines a plurality of apertures **3384** for retaining bristles or bristle tufts (not shown), a first end **3385** which engages or is disposed adjacent to the end **3376** of the movable bristle carrier **3370**, and a ridged member **3382** disposed along the underside of the tip **3380**. By "stationary" it is meant that the carrier tip **3380**, once assembled and engaged with the brush head **3314**, is generally secured to the brush head **3314** and does not move with the bristle carrier **3370**. Preferably, the ridged member **3382** is sized in a similar fashion and configuration as the ridged member **3372** of the bristle carrier **3370**. Both of the ridged members **3372** and **3382** are preferably retained within channel **3311** defined in the brush head **3314**.

One or more threaded fasteners **3390** and **3392** may be utilized to affix the body **3312** to the end cap **3320**. It will be understood that other techniques or components may be utilized to assemble the housing together.

Upon operation of the preferred embodiment toothbrush **3300**, an electrical circuit is completed between a power source such as a battery and the motor **3350**. Details as to the power source and electrical operating characteristics of the motor are provided herein. Rotation of the drive gear **3354** causes rotation of the crown gear **3356**. Preferably, the axis of rotation of the crown gear **3356** is perpendicular or transverse to the axis of rotation of the drive gear **3354**. Rotation of crown gear **3356** imparts a reciprocating motion to the drive shaft **3360** extending within the hollow interior region defined within the body **3312**, neck **3316**, and optionally the head **3314**. The distal end **3364** of the drive shaft is engaged with the movable bristle carrier **3370**, and so, imparts a corresponding reciprocating motion to the carrier **3370**.

Fig. 49 illustrates another preferred embodiment toothbrush **3400** in accordance with the present invention. The toothbrush **3400** includes a body portion **3412**, a neck portion **3416**, and an end cap **3420**. The body portion **3412** defines a first end **3418** and an opposite end **3404** which preferably includes a screw member or threaded region. The end cap **3420** defines a closed end **3422** and an opposite open end **3424**. The open end **3424** is sized and configured to releasably engage the end **3418** of the body portion **3412**. An O-ring or other sealing member **3419** is preferably used at the interface between the ends **3424** and **3418**. The neck **3416** includes an end **3417** and a brush head **3414** preferably integrally formed at the end of the neck **3416** opposite the end **3417**. The end **3417** preferably includes provisions for releasably engaging a screw member defined at the end **3404** of the body member **3412**. The brush head **3414** preferably includes a first channel member **3411** and an aperture **3403** which provides access to a hollow region extending within the brush head **3414** and neck region **3416**. An optional second channel **3402** may be defined along the brush head **3414** which further provides guidance for a movable bristle carrier described in greater detail herein. A guide wall **3415** is preferably defined along

the brush head **3414** and may extend around a portion of the periphery of the surface of the brush head.

The preferred embodiment toothbrush **3400** further includes a motor **3450** providing a powered drive shaft **3452**. An electrical switching circuit and a power source, although not shown, are preferably retained within the hollow region defined within the body **3412** and end cap **3420**. A lower motor mount **3430** and an upper motor mount **3440** preferably cradle and retain the motor **3450** within the interior hollow region defined within the body **3412** and end cap **3420**. The interior hollow region extends within the neck **3416** and optionally within a portion of the brush head **3414**. The lower motor mount **3430** includes a base or aperture **3436** for receiving a pivot or axle member **3458** for a drive gear described in greater detail herein. The lower motor mount **3430** includes an inner drive support **3432** and an outer drive support **3434** as shown. The upper motor mount **3440** includes a drive support **3442** which preferably engages with the inner and/or outer drive supports **3432** and **3434** of the lower motor mount **3430**. A drive housing **3444** is also provided which preferably engages the motor mount **3440**. A plurality of engagement legs **3446** are preferably formed from the upper motor mount **3440** which engage the lower mount **3430**. As previously noted with regard to Fig. 48, it will be appreciated that a one-piece motor mount component may be utilized.

A drive gear **3454** which is secured to the drive shaft **3452** of the motor **3450** is preferably in engagement with a crown gear **3456**. The crown gear is rotatably supported by the axle or pivot member **3458** which in turn is received in the base **3436** of lower motor mount **3430**. The crown gear **3456** includes a centrally located guide member **3457** and an offset member **3455**. The offset member **3455** is engaged with a pinion end **3462** of a drive shaft component **3461**. The drive shaft component **3461** includes an end **3463** defined oppositely from the pinion member **3462**. Also provided is another drive shaft member **3466** which includes an end **3465** and an opposite end **3464**. The end **3465** preferably engages the end **3463** of the drive shaft component **3461**. The opposite end **3464** of the drive shaft component **3466** preferably engages a movable bristle carrier described in greater detail herein. The drive shaft components **3466** and

3461 preferably reside within the interior hollow region of the body **3412** and neck **3416**. A releasable and protective cover **3413** preferably is attached along a recessed region or one or more apertures defined within the body **3412**. The cover **3413** serves as a protective housing or cover for a switch, the position of which may be changed through the cover **3413**.

The preferred embodiment toothbrush **3400** also comprises a movable bristle carrier **3470** and a stationary bristle carrier tip or end **3480**. The movable bristle carrier **3470** defines a plurality of apertures **3474** for receiving and retaining a plurality of bristles and bristle tufts (not shown). The bristle carrier **3470** includes a first end **3475** and an opposite second end **3472**. The end **3475** is preferably shaped and sized to fit within the channel **3411** defined along the brush head **3414** and preferably having a similar configuration as the guide wall **3415**. The movable bristle carrier **3470** also includes a ridged member **3476** along its underside, sized to engage the channel **3411** defined along the brush head **3414**. The distal end **3464** of the drive shaft component **3466** is engaged with the bristle carrier **3470**. Preferably, the end **3464** is accessible through aperture **3403** defined in the brush head **3414**.

The bristle carrier tip **3480** includes a plurality of apertures **3484** adapted for receiving and retaining bristles or bristle tufts (not shown). The bristle carrier tip **3480** also includes a first end **3485** adapted to face the end **3472** of the movable bristle carrier **3470** and portions of the guide wall **3415** of brush head **3414**. The bristle carrier tip **3480** also includes an opposite end **3482** and may further include a ridged member **183** along its underside, to engage and reside within the channel **3411** defined within the brush head **3414**. The ridged member **3483** is preferably configured in a similar fashion as the ridged member **3476** of the bristle carrier **3470**. Upon assembly, the bristle carrier tip **3480** is secured to the distal end of the brush head **3414**.

The preferred embodiment toothbrush **3400** operates in a similar fashion as the previously described preferred embodiment toothbrush **3300**. Upon completion or closure of an electrical circuit between the motor **3450** and a power source, the drive shaft **3452** and drive gear **3454** rotate. Such rotation causes rotation of the crown gear **3456** and imparts a reciprocating motion to the

drive shaft members or components **3461** and **3466**. Engagement between the drive shaft component **3466** and the bristle carrier **3470** imparts a translating or reciprocating movement to the carrier **3470**.

The present invention toothbrushes, and particularly the preferred embodiment toothbrushes **3300** and **3400**, have been found to operate utilizing remarkably minor amounts of power. And surprisingly, these electric toothbrushes provide comparable brushing efficacy and performance as other commercially available toothbrushes. These dramatic gains are believed to result from a combination of one or more of the following factors: (1) the use of translating or reciprocating motion for the movable bristle carrier during operation of the present invention toothbrushes; (2) the selection of the degree or extent of motion of the bristle carrier, i.e. its "stroke"; (3) the particular type of motor utilized in the toothbrushes; (4) the operating speed employed by the motor; (5) the gear ratio between a motor drive gear and a crown gear used in the drive mechanism of the present invention toothbrushes; (6) the particular assembly of components used in the drive mechanism and the relatively few number of components; (7) the use of static bristles in conjunction with movable bristles; and (8) the particular bristle configuration employed along the brush head.

The present invention approach of using a translating plate to impart motion to a plurality of bristles has been found to provide significant improvement in reducing energy consumption and operating current and voltage requirements as compared to currently known electric toothbrush assemblies. For example, comparative tests between (i) Assignee's relatively energy efficient and hugely popular Crest⁷ Spin Brush⁷ using an oscillating spin head and (ii) a translating or reciprocating bristle carrier according to the present invention, reveals the following:

TABLE 2

	Spin Head	Translating Plate
Voltage to Initiate Movement (Under 1 lb. Loading)	>1.8 V	>1.28 V
Current Draw at 3.0 V (under 1 lb. Loading)	0.8 A	0.5 A

The data presented in Table 2 illustrates that a preferred embodiment toothbrush according to the present invention and utilizing a translating plate or bristle carrier requires significantly less voltage (approximately 28%) and less amperage (approximately 37%) than a leading commercially successful toothbrush utilizing an oscillating or spin head configuration.

Another aspect of the high efficiency drive mechanisms according to the present invention relates to the stroke length of the movable bristle carrier, such as bristle carriers 3370 and 3470. The preferred parameters of the movement of the reciprocating bristle carrier are as follows. Preferably, the reciprocating carrier has a stroke length at least about 0.5 mm, more preferably at least about 1.0 mm, more preferably at least about 1.25 mm, and most preferably at least about 1.5 mm; and less than about 5 mm, more preferably less than 3.5 mm, more preferably less than 2.5 mm, and most preferably less than 1.7 mm. It will be appreciated that the present invention drive mechanisms may utilize stroke lengths greater or lesser than these various preferred values. Although not wishing to be bound to any particular theory, it is believed that excessive amounts of power, i.e. battery power, are consumed when stroke length is excessively long. And, if stroke length is too short, brushing efficacy is greatly reduced. As previously noted, the direction of movement of the bristle carrier is parallel with the longitudinal axis of the toothbrush.

The motor used in the preferred embodiment toothbrushes described herein is preferably particularly adapted to provide a high efficiency power source for the drive mechanism. A standard motor may be modified by using less windings and reducing the voltage requirements to about 1.5 volts. Typical standard motors exhibit general current draw characteristics as follows: Without loading, a draw of about 1.06 amps is required, and with loading, a draw of at least 1.0 amp is required. The preferred embodiment motors used in the electric toothbrush embodiments described herein draw less than 0.3 amps without a load, and approximately 0.4 to about 0.6 amps under a load. The "loads" referred to are typical operating loads placed upon the motor when operating the preferred embodiment toothbrushes described herein during routine

brushing.

The preferred operating speed for the motors used in the preferred embodiment toothbrushes described herein ranges from about 1500 rpm to about 3500 rpm, and is most preferably about 2500 rpm. An rpm of 2500 provides about 1250 stroke cycles per minute as measured at the reciprocating bristle carrier when utilizing the preferred embodiment drive mechanisms described herein. These operating speeds are given with respect to the motor engaging the drive mechanism, however, no brushing load being placed upon the bristle carrier. It will be appreciated that upon application of a load to the motor, the operating speed of the motor may be reduced by about 30% to about 35%. These values are estimates and the extent of reduction in operating speed will depend upon a host of factors.

This relationship of motor operating speed and bristle carrier stroke speed is an indication of the preferred gear ratio between the drive gear engaged to the drive shaft of the motor (such as drive gear 3354 in Fig. 48 or drive gear 3454 in Fig. 49) and the crown gear (such as crown gear 3356 in Fig. 48 or crown gear 3456 in Fig. 49) to which the drive shaft is engaged at the offset member. The preferred ratio is from about 1:1 to about 3:1, and most preferably about 2:1. Therefore, at this most preferred ratio, for every two revolutions of the motor drive shaft, the crown gear rotates once. The noted preferred gear ratio of 2:1 has been found to provide a desirable combination of range of motion and speed as measured at the bristle carrier to provide excellent brushing characteristics in conjunction with an acceptable level of power consumption.

The use of the noted crown gear in the preferred embodiment drive mechanisms described herein is particularly desirable since that type of drive component, and its orientation shown in the referenced figures, requires relatively few components and enables a relatively small housing to be utilized since the resulting overall volume of the drive mechanism is small. The preferred crown gear used in the drive mechanism described herein utilizes from about 8 or 10 to about 40 gear teeth. Most preferably, the crown gear has about 20 gear teeth. This is a relatively small number of teeth for the given size and application of the crown gear. This results in a relatively tall profile for the gear teeth of the crown

gear. Accordingly, the preferred crown gears of the present invention utilize an offset member that must extend above the height of the gear teeth. This is necessary so that sufficient clearance is provided for the gear teeth of the crown gear. The crown gear is rotatably supported by an axle having a height such that the drive shaft engaged with the offset member is aligned with the bristle carrier. This particular arrangement and combination of components provides a drive mechanism utilizing a remarkably few number of components. The fewer the number of components, the more efficient is the transfer of motion and greater ease in assembly and production.

Referring to Fig. 50, a portion of a preferred embodiment drive mechanism is shown. A motor 3550 providing a powered drive shaft 3552 and a drive gear 3554 secured to the shaft 3552 is engaged with a crown gear 3556. The crown gear 3556 is rotatably supported at its center 3557 by an axle 3558. An outwardly extending offset member 3555 is provided along an outer face 3551 of the crown gear 3556. The member 3555 is disposed radially outward from the center 3557 of the crown gear 3556. A drive shaft 3560 is engaged at its end 3562 with the offset member 3555. Upon rotation of the drive shaft 3552 and gear 3554, the crown gear 3556 rotates about axle 3558. That movement in turn imparts a reciprocating motion to the drive shaft 3560.

Fig. 51 is a side elevational view of the portion of the preferred embodiment drive mechanism depicted in Fig. 50. Fig. 51 illustrates a feature of the preferred embodiment drive mechanisms, that of the elevated orientation of the reciprocating drive shaft with respect to the crown gear. Specifically, it can be seen that the gear teeth of the crown gear 3556 have a profile or overall height shown as height *G*. The offset member 3555 is engaged with the drive shaft 3560 such that a distance *S* is maintained between the shaft 3560 and the gear teeth. Most preferably, the distance *S* is also the distance necessary to maintain alignment between the offset member 3555 and the bristle carrier disposed on the brush head. Most preferably, the drive shaft 3560 is the only drive component extending between and engaging those components.

As previously noted, another aspect of the preferred embodiment toothbrushes, and particularly, of the drive mechanisms described herein, is that

a relatively few number of drive components are utilized. This is readily apparent from the exploded views in Figs. 48 and 49. This design strategy reduces the number of interconnections and engagements between drive components and so a more direct assembly of drive components is achieved. This approach greatly simplifies assembly, reduces overall costs of production, and leads to a more commercially viable consumer product.

Additionally, the use of static bristles in combination with a plurality of movable bristles, assists in reducing the overall load on the reciprocating bristle carrier. Figs. 52-54 illustrate this feature in greater detail. Fig. 52 illustrates a portion of a preferred embodiment toothbrush 3600 comprising a brush head 3614, a neck 3616, a movable bristle carrier 3670, and an end component 3680. The movable bristle carrier 3670 supports and retains a plurality of bristles 3650, designated herein as movable bristles. These are shown in dashed lines for clarity. The end component 3680 supports and retains a plurality of bristles 3662, designated herein as stationary bristles. Additionally, the brush head 3614 supports and retains a plurality of bristles 3660, also designated herein as stationary bristles, that preferably, are disposed along the periphery of the movable bristle carrier 3670 and the bristles 3650 disposed thereon. The stationary bristles 3662 and 3660 are also shown in dashed lines.

The bristle configuration shown in Fig. 52 is significant in that the plurality of bristles that are stationary, i.e. bristles 3660 and 3662, essentially surround or partly so, the movable bristles 3650 retained on the movable bristle carrier 3670. This configuration has been found to reduce the load otherwise applied to the bristles 3650 and movable bristle carrier 3670 during brushing and operation of the toothbrush 3600. This characteristic is believed to result from the stationary bristles 3660 and 3662 accommodating a portion of the brushing load, otherwise placed upon the bristles 3650 and carrier 3670. The distribution of the brushing load between the stationary bristles 3660 and 3662, and the movable bristles 3650, is determined by a number of factors including, but not limited to: (i) the relative heights of the stationary and movable bristles, (ii) the materials forming the stationary and movable bristles, (iii) the profile of the brushing surface resulting from the distal ends of the stationary and movable

bristles, (iv) the respective densities (or bristles per unit area) of the stationary and movable bristles, and (v) the arrangement of the stationary bristles and movable bristles. By adjusting one or more of these factors, the load applied to the movable bristle carrier during brushing may be reduced by, for example, increasing the relative height of the stationary bristles or decreasing the height of the movable bristles. The load applied to the movable bristle carrier may also be reduced by increasing the density of the stationary bristles disposed around the movable carrier. The load may also be reduced by selecting particular materials that exhibit a high degree of stiffness for the stationary bristles as compared to the movable bristles.

Fig. 53 illustrates another preferred embodiment toothbrush 3700 comprising a brush head 3714, a neck 3716, a movable bristle carrier 3770, a plurality of movable bristles 3750 supported and retained on the carrier 3770, a first plurality of stationary bristles 3760 disposed on the brush head 3714, and a second plurality of stationary bristles 3762 disposed on the end of the brush head 3714. This toothbrush embodiment 3700 utilizes a bristle configuration in which a large number of stationary bristles, such as 3760 and 3762, are disposed around the movable bristles 3750, or substantially so. It will be noted that the group of stationary bristles 3762 are primarily disposed along the end of the brush head 3714. And, the other group of stationary bristles 3760 generally extend around the remaining periphery of the movable bristle carrier 3770. This arrangement has been found to offer good brushing efficacy and significant reductions in brushing loads otherwise applied to the bristles 3750 and thus, the bristle carrier 3770.

Fig. 54 illustrates another preferred embodiment toothbrush 3800 comprising a brush head 3814, a neck 3816, a movable bristle carrier 3870, a plurality of movable bristles 3850 supported and retained thereon, and a plurality of stationary bristles 3860 extending generally around the periphery of the bristle carrier 3870. In this embodiment, the stationary bristles 3860 extend around at least a majority of the outer periphery of the bristle carrier 3870. Preferably, the bristles 3860 extend continuously, or substantially so, around the movable bristle carrier 3870 and the movable bristles 3850 disposed thereon. It is not necessary

that the stationary bristles **3860** be disposed in a region adjacent the movable bristle carrier that is opposite the distal end of the brush head **3814**. This region is shown in Fig. **54** as region **3864**. This particular bristle arrangement has been found to offer good brushing performance and significant reductions in brushing loads otherwise applied to the bristles **3850** and thus, the bristle carrier **3870**.

Figs. **53** and **54** also illustrate brush heads utilizing different bristle densities along their distal ends, such as in the region of a bristle carrier tip, such as tip **3380** in Fig. **48**. These regions are shown in dashed lines. The dashed region of Fig. **53** contains six bristle tufts per unit area whereas Fig. **52** contains five bristle tufts per unit area.

Another significant aspect that the present invention provides is a unique engagement assembly comprising a gear that is driven by the electric toothbrush motor and a drive shaft that powers one or more movable bristle carriers. This engagement assembly efficiently converts rotary motion of the gear to reciprocating motion of the drive shaft. The assembly operates and performs the noted conversion in a remarkably quiet and smooth manner.

This preferred engagement assembly is illustrated in Figs. **55-60**. Fig. **55** illustrates a preferred embodiment assembly **4000** comprising a drive shaft **4100** and a gear **4200**. The drive shaft **4100** includes a shaft portion **4110** and a distal end having a partially enclosed elongated end **4120** that, as described below, provides a unique set of surfaces for engagement with cam surfaces of the gear **4200**. More specifically, Fig. **55** illustrates an oval-shaped aperture **4125** defined within a central region of the partially enclosed elongated end **4120**. The partially enclosed end **4120** includes an end cover **4122** which defines the aperture **4125**. Disposed about the periphery of the end cover **4122** is an end wall **4126**. Together, the cover **4122** and the wall **4126** provide a partial enclosure (not shown in Fig. **55**) that receives certain components of the drive gear **4200**.

Fig. **55** also illustrates the preferred gear **4200** of the assembly **4000**. The gear **4200** is similar to the gear **806** shown in Fig. **12**, gear **3356** shown in Fig. **48**, gear **3456** shown in Fig. **49**, and gear **3556** shown in Figs. **50** and **51**. That is, the mounting and function of the gear **4200** is similar to the

mounting and function of those noted gears. However, the gear 4200 utilizes a unique collection of camming surfaces. Specifically, gear 4200 includes a plurality of gear teeth 4210 disposed about its periphery. A drive gear such as affixed to an electric motor is preferably engaged or otherwise coupled to the gear 4200, and specifically to the gear teeth 4210. A circular medial base 4220 extends along an outward face of the gear 4200 and between opposite regions of the gear teeth 4210. Disposed on the base 4220 and extending outward therefrom is a first cam 4230 providing a circular cam surface 4232 extending about the periphery of the cam 4230. Extending from the first cam 4230 is a second cam 4240. The second cam 4240 provides a circular cam surface 4242 extending about the periphery of the second cam 4240. It will be appreciated that the center of the second cam 4240 coincides with the center of the base 4220, and the center of the gear 4200. Thus, upon rotation of the gear 4200, such as about the axis of rotation A shown in Fig. 55, the second cam 4240 and the base 4220, rotate about the same axis, i.e. axis A. The center of the first cam 4230 is shown in Fig. 55 as axis B, is spaced from, yet preferably parallel to, axis A.

Fig. 56 is a top planar view of the gear 4200. Fig. 56 illustrates the arrangement of the first cam 4230 and the second cam 4240 with respect to each other, and the center of rotation A of the gear 4200. Again, it will be noted that the center of the circular first cam designated as center B in Fig. 56 is spaced apart from the center (or axis of rotation) A.

Fig. 57 is a side elevational view of the gear 4200. Fig. 57 further illustrates the configuration and arrangement of the gear teeth 4210, base 4220, the first cam 4230 and its cam surface 4232, the second cam 4240 and its cam surface 4242.

Fig. 58 is a partial cross-sectional side view of the assembly 4000 illustrating the elongated end 4120 of the drive shaft 4100 engaged with the gear 4200. Specifically, it can be seen that the second cam 4240 is disposed within the aperture 4125 defined in the end 4120. And, the first cam 4230 is enclosed by and received within the end 4120. Preferably, the cam surface 4242 of the second cam 4240 engages and contacts portions of the surface of the elongated end 4120 that defines the aperture 4125. And, preferably, the cam surface 4232

of the first cam **4230** engages and contacts portions of the interior and specifically, portions of an interior wall **4122** defined along the interior of the elongated end **4120**.

Fig. **59** illustrates the underside, i.e. the side of the elongated end **4120** of the drive shaft **4100** that faces the base **4220** of the gear **4200**. Fig. **59** further illustrates the interior wall **4122** which the cam surface **4232** of the first cam **4230** engages when the gear **4200** and drive shaft **4100** are engaged to form the assembly **4000**. Fig. **59** also illustrates the orientation of the aperture **4125**. Fig. **59** additionally illustrates two dimensions **S** and **T** as follows.

Dimension **S** is the minimum span or entrance dimension of the aperture **4125**. Since the second cam **4240** is received within the aperture **4125**, the diameter of the cam **4240** should be slightly less than dimension **S**. Alternatively, dimension **S** should be slightly greater than the diameter of the cam **4240**.

Dimension **T** is the minimum span or entrance dimension of the oval shaped interior wall **4122**. Since the first cam **4230** is received within the region generally bounded by the interior wall **4122**, the diameter of the cam **4230** should be slightly less than dimension **T**. Alternatively, dimension **T** should be slightly greater than the diameter of the cam **4230**.

Fig. **59** also illustrates a preferred orientation of the aperture **4125** within the end **4120**. As can be seen, the major axis of the oval shaped aperture **4125** depicted as axis **D**, is preferably parallel and most preferably co-extensive with, the longitudinal axis of the shaft portion **4110** of the drive shaft **4100**, depicted as axis **C**.

Fig. **59** additionally illustrates that the aperture **4125** is preferably oval-shaped and oriented at right angles to the oval-shaped interior region defined by the interior wall **4122**. That is, the major axis of the oval shaped aperture **4125** is preferably perpendicular to the major axis of the oval shaped interior region defined by the wall **4122**.

Fig. **60** is a top, planar view of the assembly **4000** further illustrating the arrangement, orientation, and configuration of the drive shaft **4100** and the gear **4200**. Upon rotation of the gear **4200** about axis **A**, such as in the direction

of arrow **E**, the center of the first cam **4230** is rotated about axis **A** generally along the circular path **G**. Circular path **G** results from the first cam **4230** being displaced about the axis **A** as gear **4200** rotates. It will be appreciated that the radius of the circular path **G** corresponds to the amount of offset or spacing between the center points **A** and **B** shown in Fig. 55.

As gear **4200** rotates, thus causing the first cam **4230** to be displaced about axis **A**, along the circular path **G**, a portion of the cam surface **4232** of the first cam **4230** engages various regions of the interior wall **4122**. This results in the end **4120** being linearly translated back and forth with respect to the center point of gear **4200** and axis **A**. Restated, this has the effect of causing the second cam **4240** to be linearly translated back and forth within the aperture **4125**. However, it will be appreciated that since the gear **4200** is essentially fixed at its point of rotation, i.e. axis **A**, it is the end **4120** and thus the drive shaft **4100** that is translated back and forth. The rotation of gear **4200** in the direction of arrow **E** causes reciprocation of the drive shaft **4100** in the direction of arrows **F** shown in Fig. 60.

The preferred embodiment assembly **4000** efficiently converts rotary motion of the gear **4200** into 100% or substantially so, reciprocal motion of the drive shaft **4100**. That is, there is none or only an exceedingly minor degree of motion in a direction other than along the longitudinal axis **C** of the drive shaft **4100**. This characteristic is beneficial in that upon high operating speeds, vibration of the assembly is minimal, or at least maintained to acceptable levels.

In addition to its high operating efficiency characteristics, the preferred embodiment toothbrushes described herein also provide relatively high brushing forces. An indication of this is that the preferred embodiment toothbrushes described herein provide a powered and relatively constant reciprocating stroke motion at their brush head even upon application of heavy loads. For instance, toothbrushes according to the present invention may operate under loads as high as 30 lbs applied to their brush heads and reciprocating bristle carriers.

An example of the relative high efficiency and low power consumption of the preferred embodiment drive mechanisms described herein,

relates to battery usage. Nearly all comparable currently available electric toothbrushes require two (2) AA batteries for their operation. The preferred electric toothbrushes described herein require only one (1) AA battery. It is remarkable and surprising that the present invention toothbrushes provide the same, or substantially the same, force and power characteristics at their brush heads, i.e. measured at the bristle ends, as comparable commercially available brushes; and yet only require approximately one-half of the power or battery requirements as those same brushes. It will be appreciated that in no way are the present invention toothbrushes limited to utilizing only a single (AA) battery. The present invention toothbrushes may utilize a wide variety of batteries, battery configurations, and power sources. The references to (AA) batteries are provided for ease in understanding and further describing the present invention toothbrushes and their low energy consumption characteristics. Generally, the present invention toothbrushes preferably operate from a voltage source of from about 0.5 volts to about 2.5 volts. More preferably, the present invention toothbrushes operate from a power source providing 1.5 volts. Most preferably, such a power source is rechargeable. Of course, the present invention toothbrushes may utilize disposable batteries. This "low energy consumption" feature is an aspect of the present invention toothbrushes that is particularly appealing from a commerciability standpoint.

An indication of this low energy consumption feature of the present invention toothbrushes is illustrated in the total run time of the toothbrushes. A testing apparatus was assembled in which a fixture and a one (1) pound weight were enclosed in a housing. A toothbrush that is to be tested is secured in the fixture, with its bristles directed upwards. The one pound weight is then placed on the brushing surface of the brush, i.e. the upwardly directed distal ends of the bristles. The surface of the weight corresponds to that of a typical dental surface. The toothbrush is then activated and the total elapsed time is measured until the toothbrush stops operating. Preferably, toothbrushes according to the present invention generally operate at least about 100 minutes, more preferably at least 120 minutes, more preferably at least 140 minutes, more preferably at least 160 minutes, and more preferably at least 180 minutes. It is contemplated that the

present invention toothbrushes may operate under the described conditions up to as long as 210 to 220 minutes, and even longer. The foregoing noted testing conditions utilize a single (AA) battery. Generally, these total run times are measured using a voltage source of at least about 0.9 volts to about 2.5 volts, and employing a reciprocating bristle carrier having the noted stroke lengths and speeds.

As previously noted, an additional benefit of the preferred embodiment toothbrushes described herein is their relative simple assembly. This results in reduced manufacturing costs. Furthermore, it is contemplated that the preferred embodiment drive assemblies described herein will provide increased reliability due to their simple and straightforward design. And, the relatively few number of components employed in these drive assemblies further reduces the potential for failures at their interconnections.

In the event a pinned engagement assembly is utilized, it is most preferred that the movable bristle carrier define an aperture accessible from its underside, similar to aperture 3254 illustrated in Fig. 47. Such aperture may extend only partially through the thickness of the bristle carrier (as shown in Fig. 47), or may extend entirely through that thickness to the other, top side of the carrier. The drive shaft, and specifically, the distal end, such as end 3206 shown in Fig. 47, is formed to either have a pin or pin-like extension from its distal end, or be adapted to engage a separate pin component. The pin (either a separate component or formed as part of the shaft) is fitted within the aperture defined in the bristle carrier. Other engagement assemblies are contemplated for use in conjunction with the present invention including, but not limited to, multiple pin engagement assemblies, latching mechanisms, threaded fasteners, and assemblies which are affixed together with adhesive or sonic welding.

It is contemplated that the various brush head tips described herein may be readily replaceable, and preferably, interchangeable with other brush head tips. Thus, a user could select a particular brush head tip from an assortment of different types and configurations. Upon selection, the user could readily attach that tip to a desired toothbrush. Furthermore, it is envisioned that so-called variety packs or sample packs, each containing various types of brush

head tips could be provided separately or in conjunction with an electric toothbrush. Similarly, if the movable bristle carriers described herein utilize a readily releasable engagement mechanism for connection to the drive mechanism, similar collections or assortments of bristle carriers could be promoted separately or in conjunction with the electric toothbrush.

It will be appreciated that any of the features and aspects of any of the preferred embodiment toothbrushes described herein may be combined with one or more of the features and aspects of other preferred embodiments described herein.

The present invention may utilize features, aspects, components, materials, and characteristics from one or more of the following published patent applications or issued patents: WO 01/29128; U.S. Patent 6,000,083; U.S. Des. Patent 432,312; U.S. Des. Patent 433,814; U.S. Patent 6,178,579; U.S. Patent 6,189,693; U.S. Patent 6,311,837; U.S. published patent application 2002/0032941; U.S. Patent 6,360,395; and U.S. Patent 6,371,294; all of which are hereby incorporated by reference.

Other than the particular materials noted or described herein, the various preferred embodiment toothbrushes and their components may be formed from conventional materials typically utilized for producing electric toothbrushes. Generally, the handle, neck, brush head, and other structural parts or components are formed from polypropylene. Polymeric blends for these parts or components may be used such as for example blends of ABS and one or more of Celcon™, Acetal™, and/or Delrin™. A wide array of self-lubricating materials are particularly preferred for forming drive train components.

The present invention has been described with reference to particular preferred embodiments. Modifications and alterations will occur to others upon reading and understanding this specification. Although certain arrangements for the static and movable bristles have been shown and described, the present invention includes a variety of other configurations. It is intended that all such modifications and alterations are included insofar as they come within the scope of the appended claims or equivalents thereof.

WHAT IS CLAIMED IS:

1. An electric toothbrush, comprising:

a body;

a neck extending from the body;

a head attached to the neck, the head having a first side and a second side opposite the first side and a movable bristle holder with bristles and a plurality of static bristles that substantially encircle the movable bristle holder; and

a motor disposed in the body and operatively connected to the movable bristle holder for moving the movable bristle holder.
2. The electric toothbrush of claim 1, wherein the movable bristle holder reciprocates, rotates, or oscillates.
3. The electric toothbrush according to claims 1 or 2, wherein the static bristles completely encircle the movable bristle holder.
4. The electric toothbrush according to any of the preceeding claims, wherein some of the static bristles are grouped into tufts that are arranged in a plurality of rows and wherein the plurality of rows comprises at least one row located along a portion of the first and second sides of the head.
5. The electric toothbrush of claim 4, wherein the rows that are located along a portion of the first and second sides of the head also extend along the length of the movable bristle holder.

6. The electric toothbrush according to any of the preceeding claims, wherein the free ends of some of the plurality of static bristles form an inclined brushing surface.
7. The electric toothbrush according to any of the preceeding claims, wherein the free ends of some of the bristles of the movable bristle holder form an inclined brushing surface.
8. The electric toothbrush according to any of the preceeding claims, wherein the bristles of the movable bristle holder that form the inclined brushing surface are grouped into a plurality of tufts that together form the inclined brushing surface.
9. The electric toothbrush according to any of the preceeding claims, wherein the free ends of some of the bristles of the movable bristle carrier form an arcuate surface.
10. The electric toothbrush of claim 9, wherein the bristles of the movable bristle holder that form the arcuate surface are grouped into a plurality of tufts that together form the arcuate surface and wherein the movable bristle holder has a longitudinal axis and the arcuate surface has a valley that extends along the longitudinal axis of the movable bristle holder.

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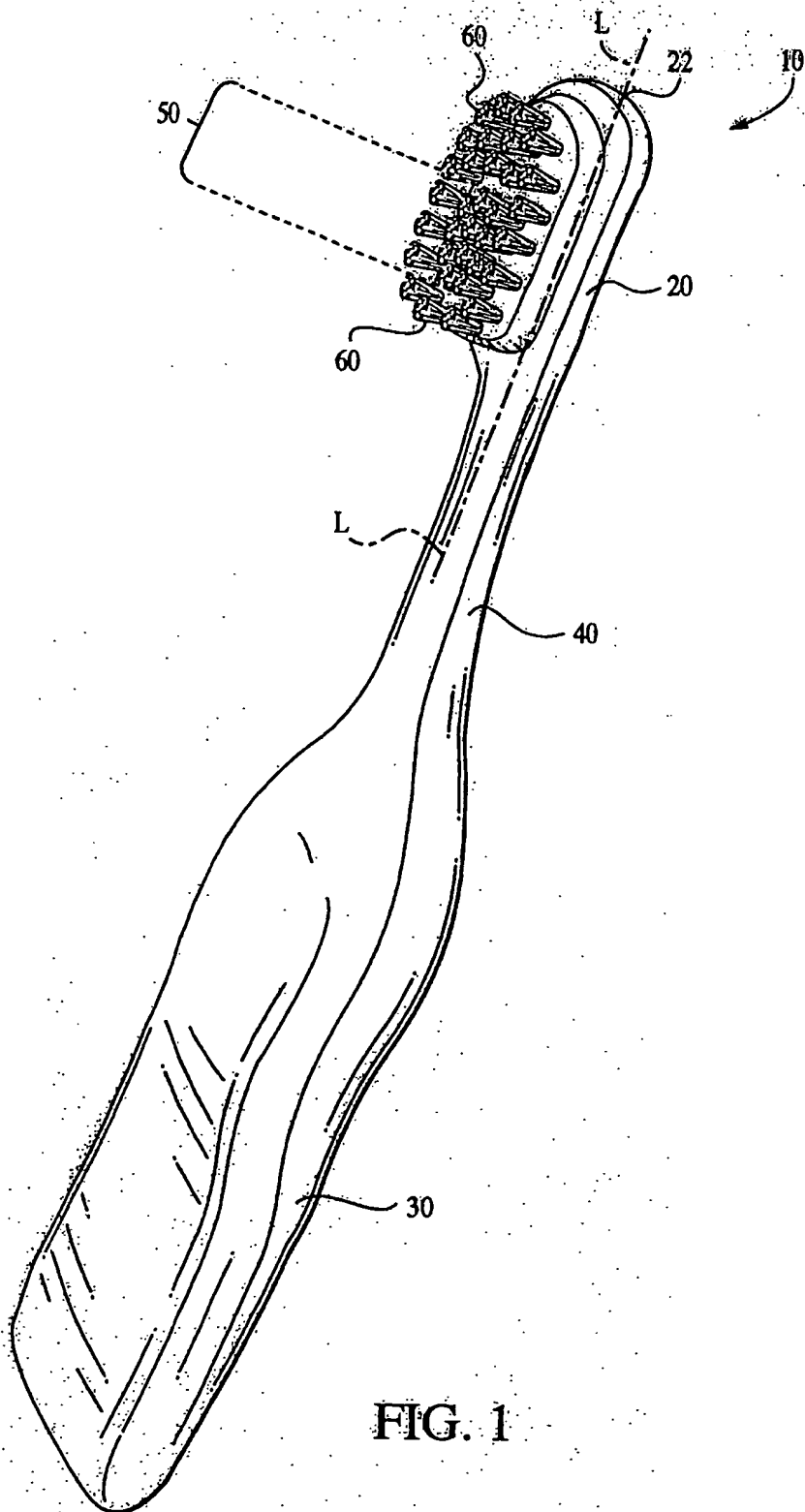


FIG. 1

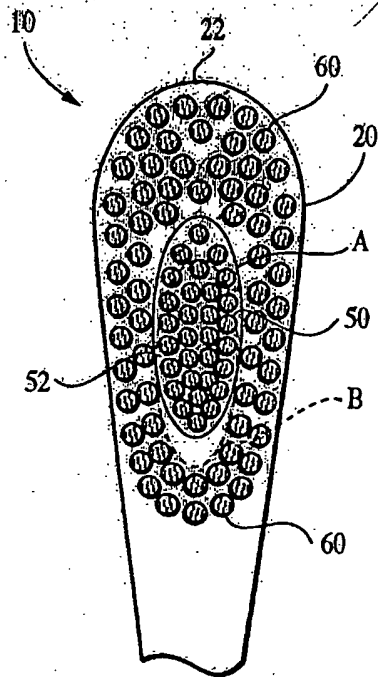


FIG. 2

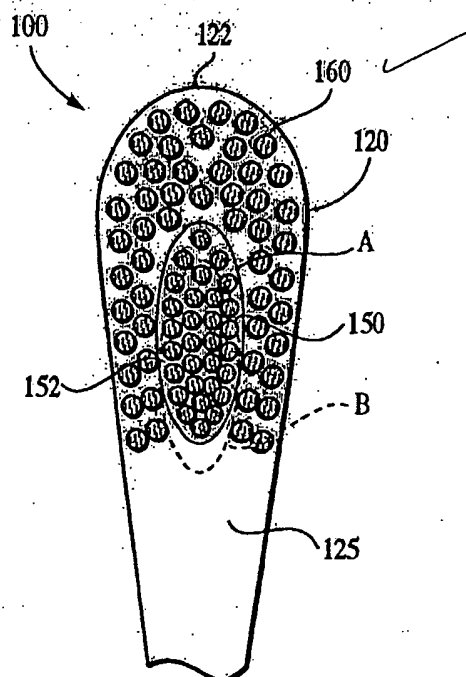


FIG. 3

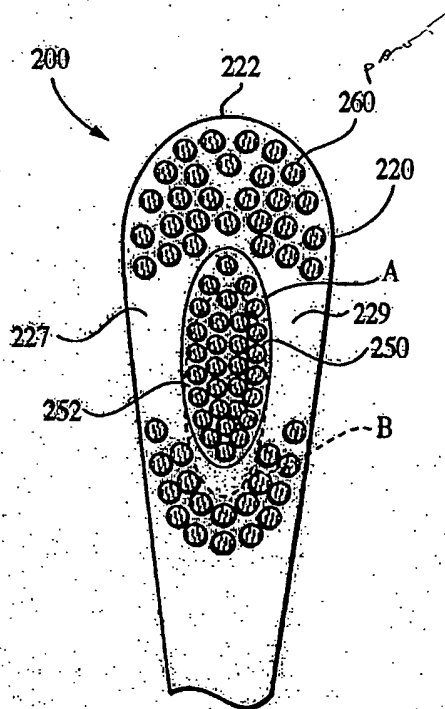


FIG. 4

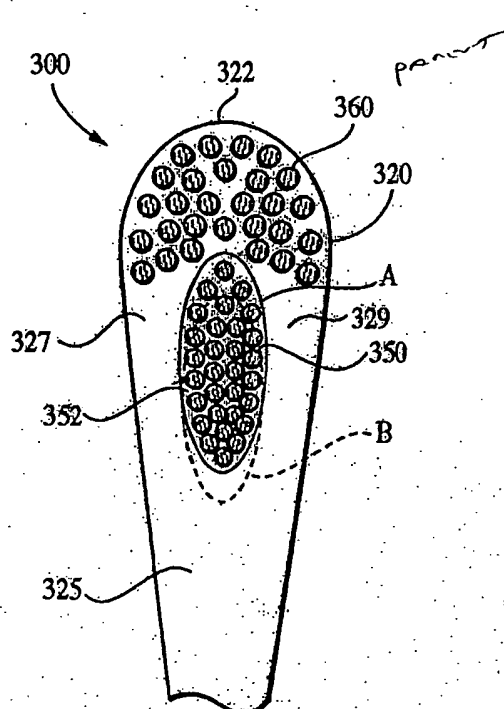


FIG. 5

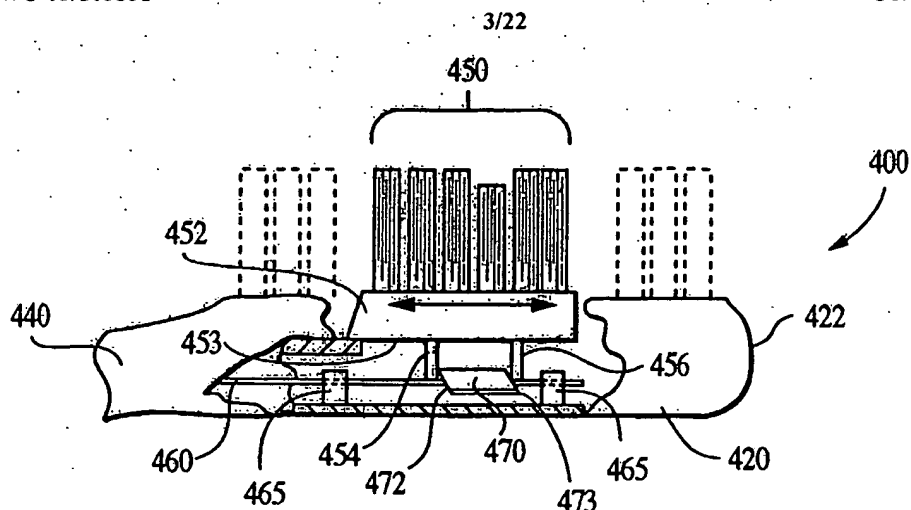


FIG. 6

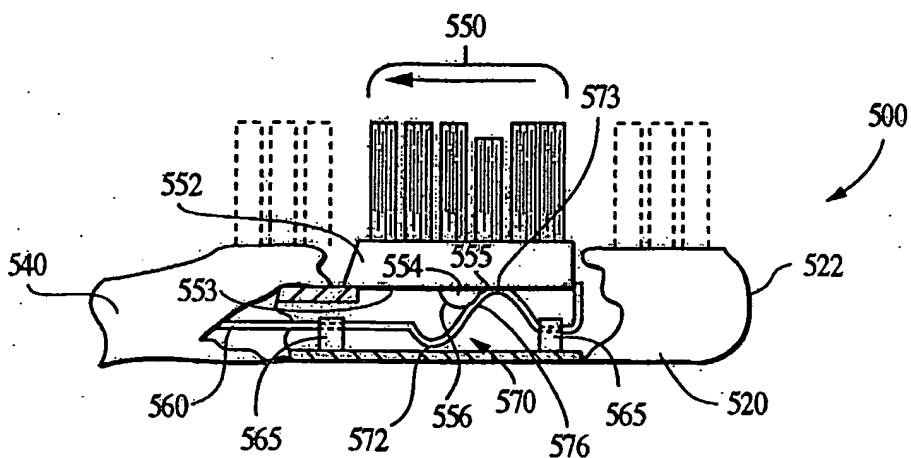


FIG. 7

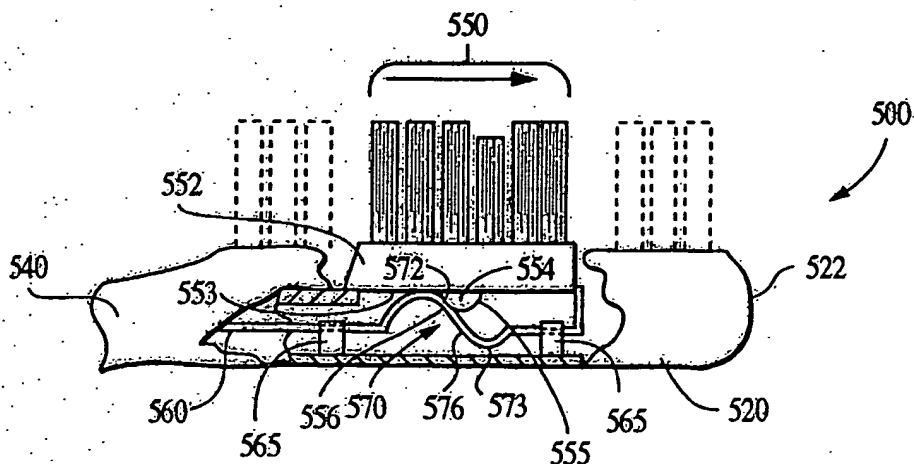


FIG. 8

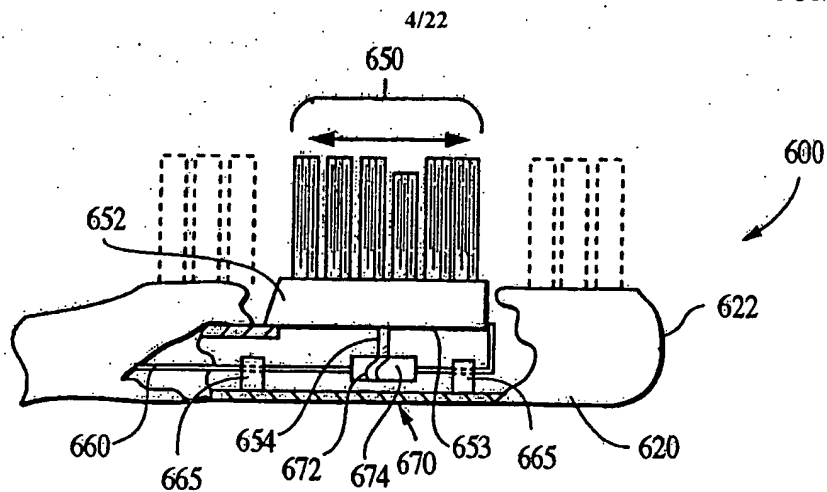


FIG. 9

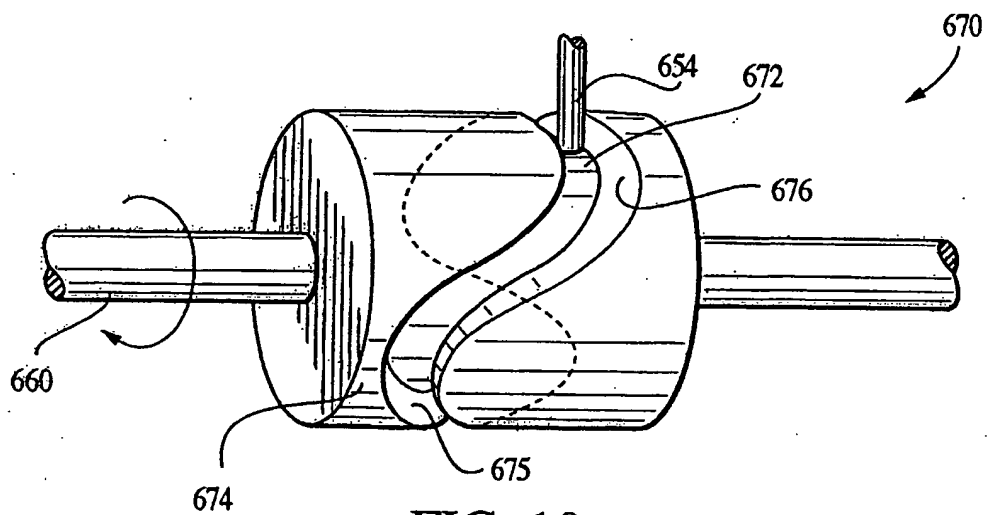


FIG. 10

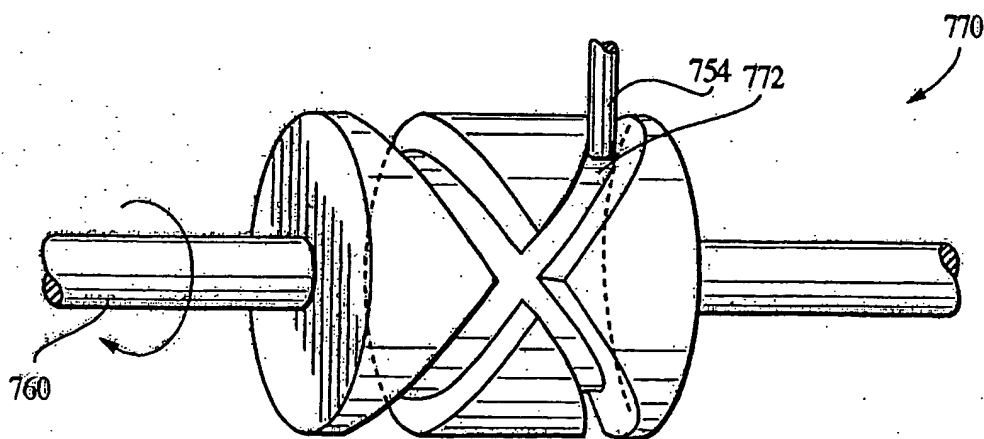
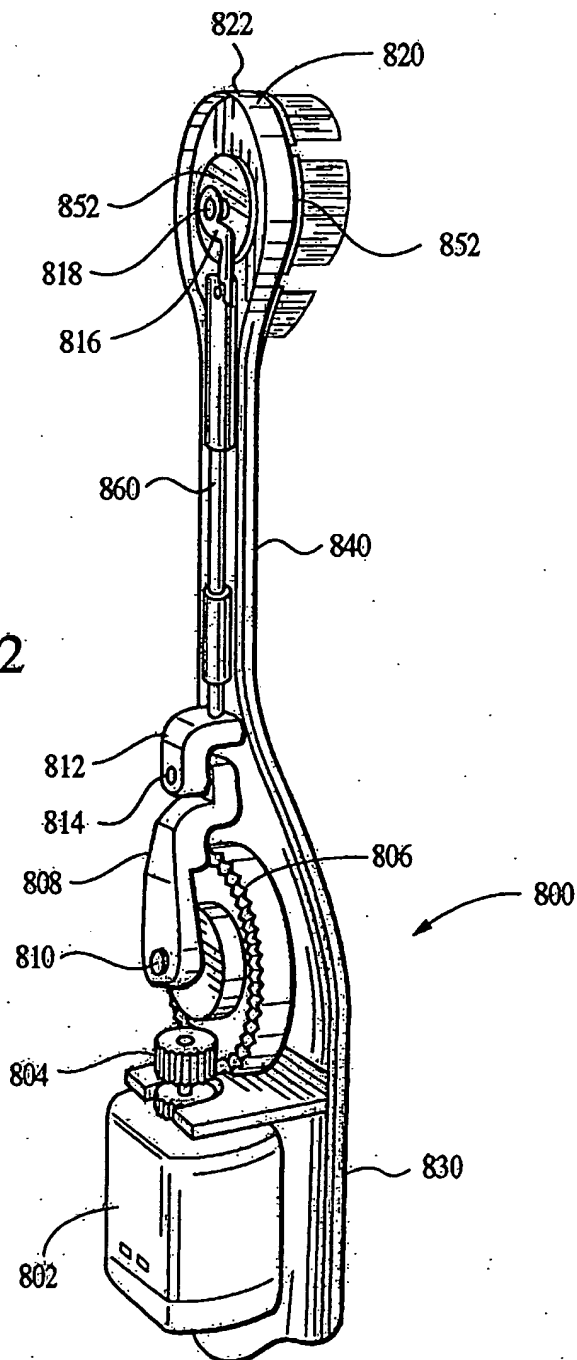


FIG. 11

FIG. 12



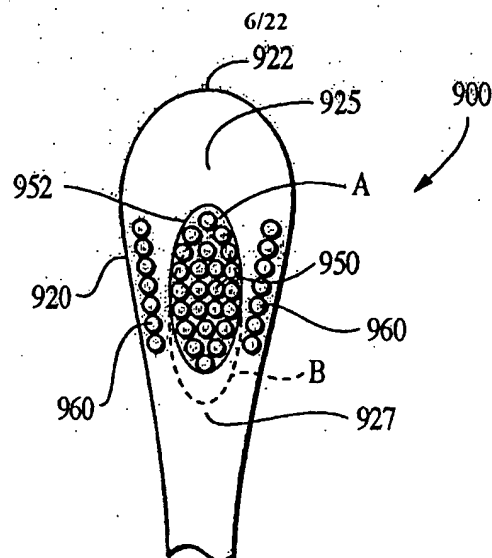


FIG. 13

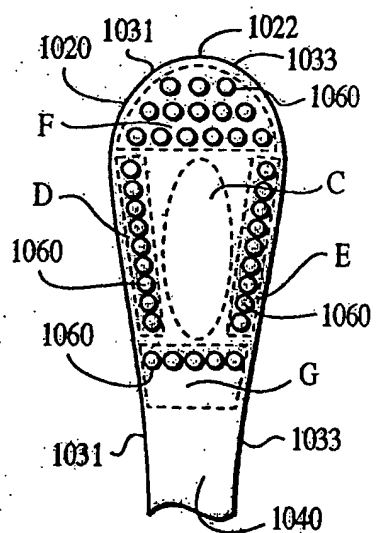


FIG. 14

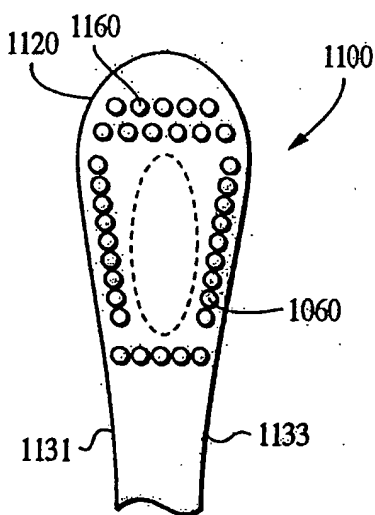


FIG. 15

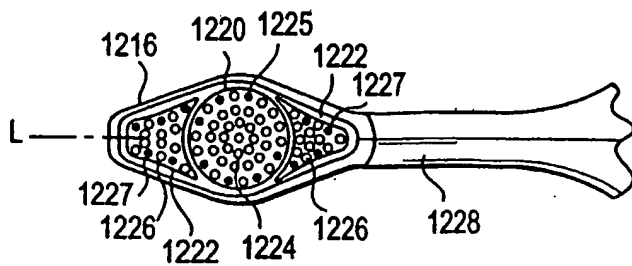


FIG. 16

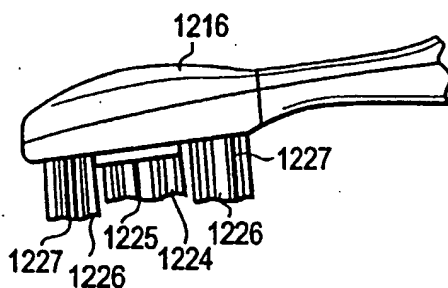


FIG. 17

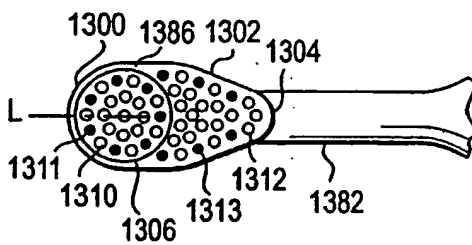


FIG. 18

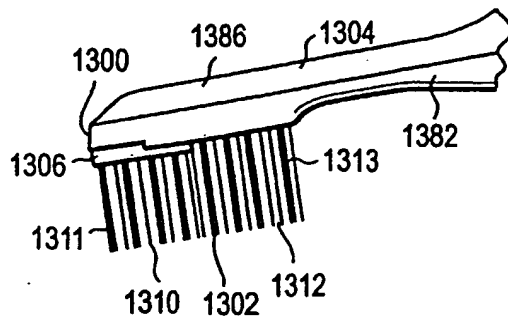


FIG. 19

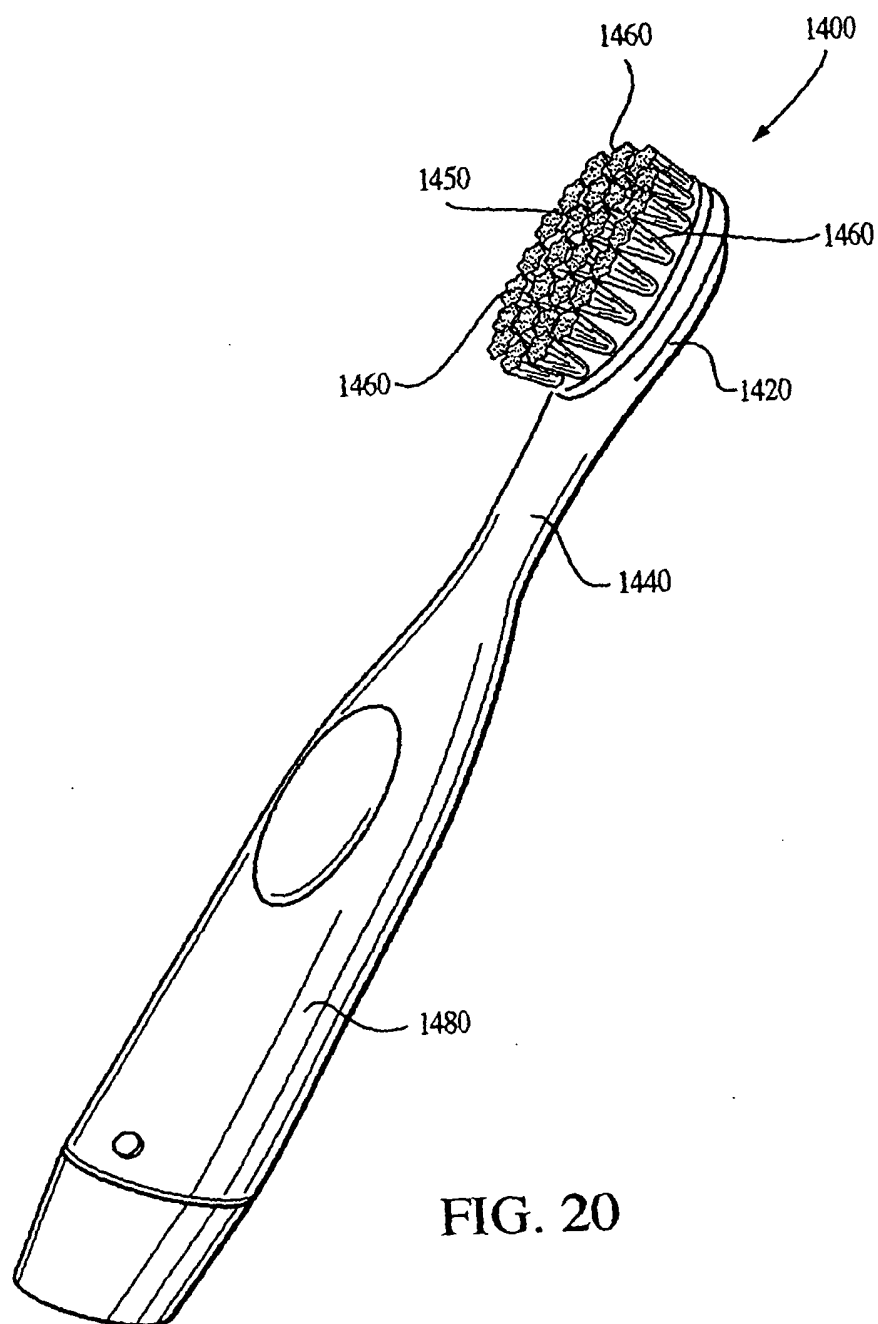


FIG. 20

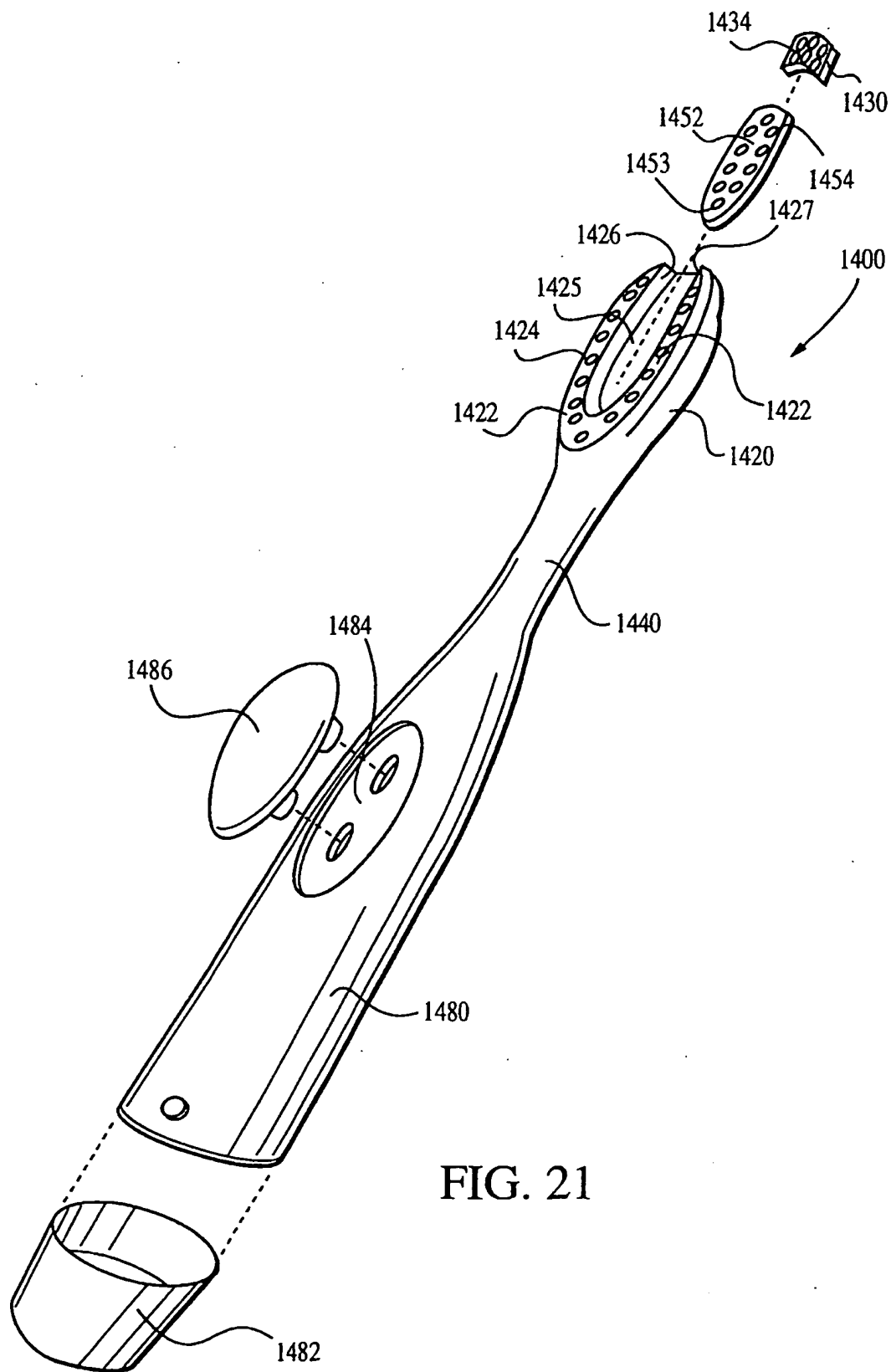


FIG. 21

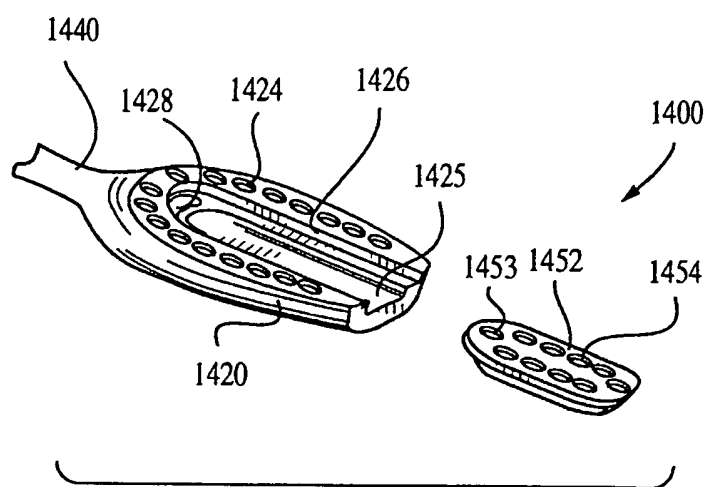


FIG. 22

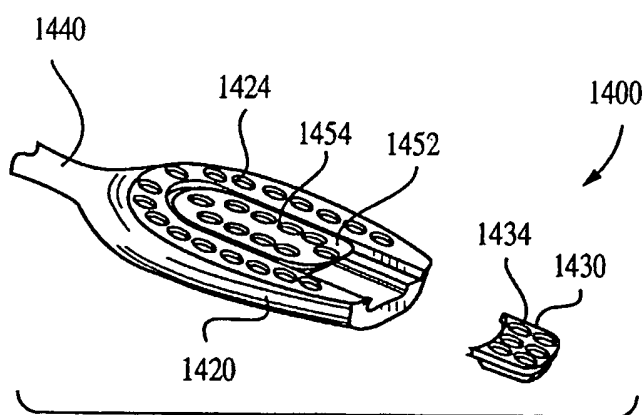


FIG. 23

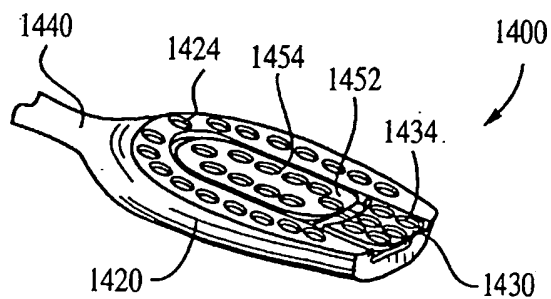


FIG. 24

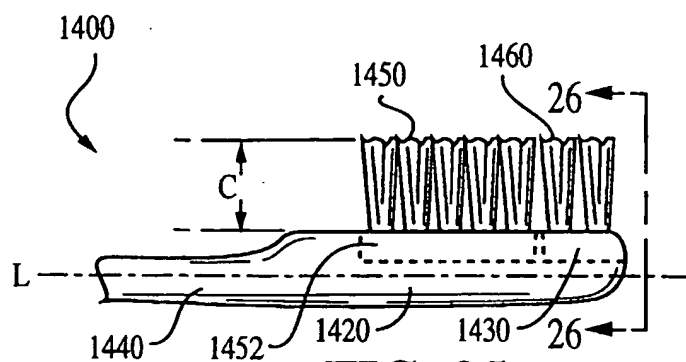


FIG. 25

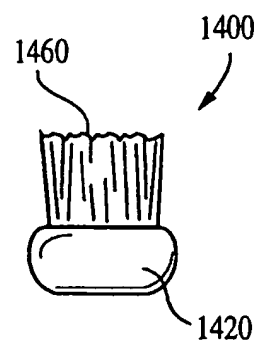


FIG. 26

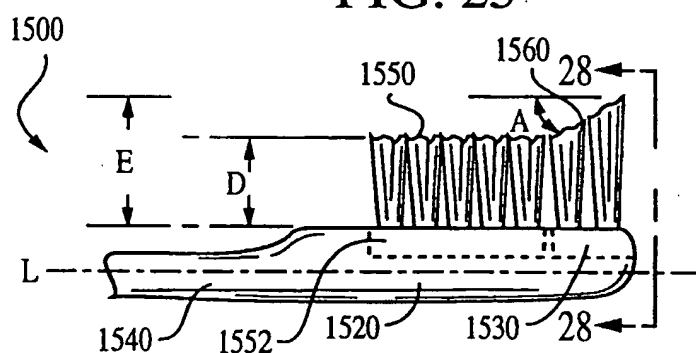


FIG. 27

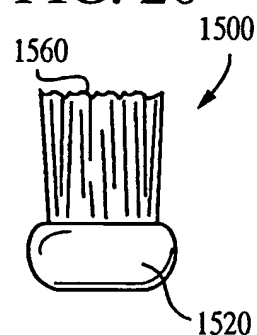


FIG. 28

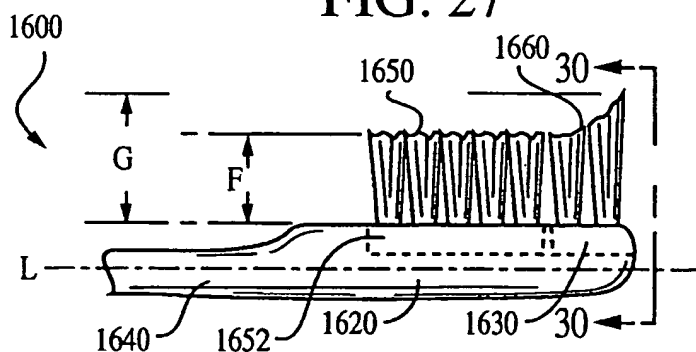


FIG. 29

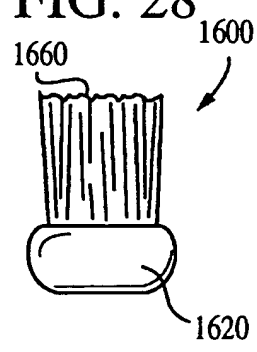


FIG. 30

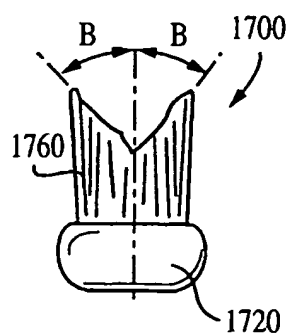


FIG. 31

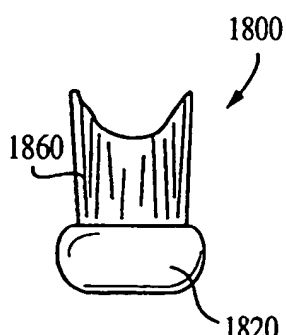


FIG. 32

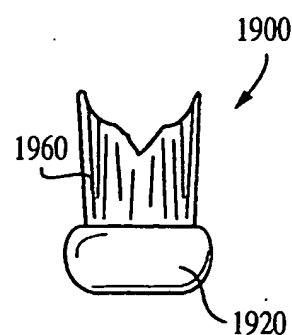


FIG. 33

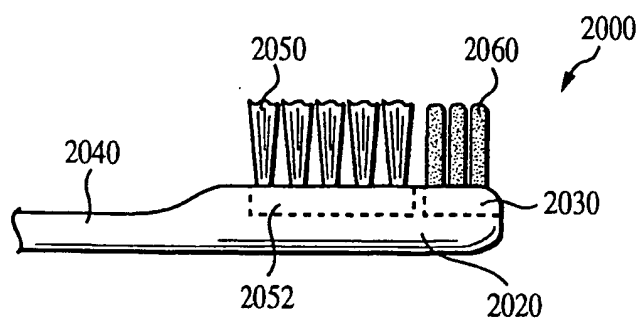


FIG. 34

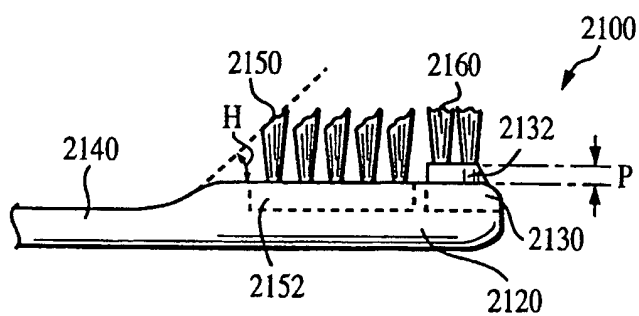


FIG. 35

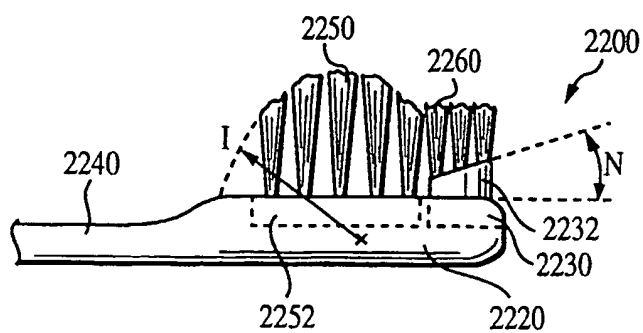


FIG. 36

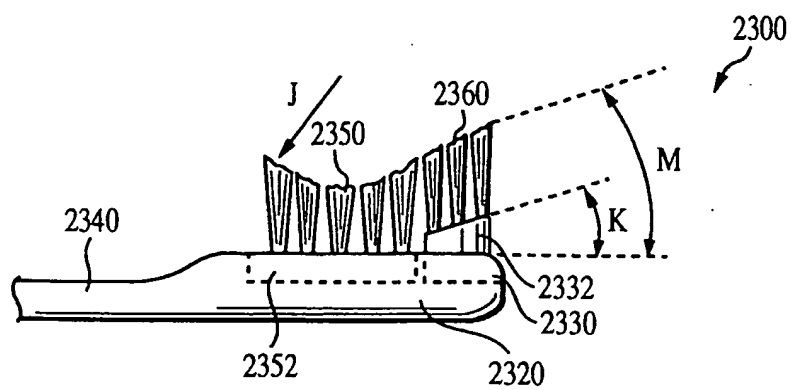


FIG. 37

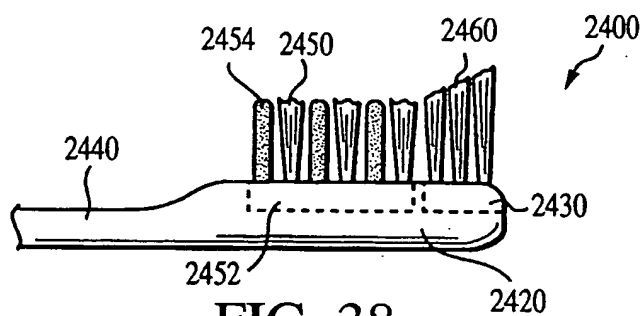


FIG. 38

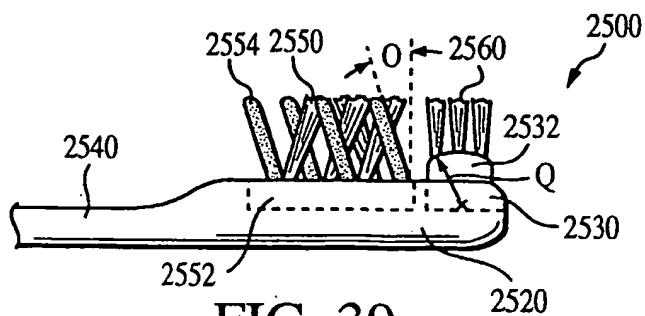


FIG. 39

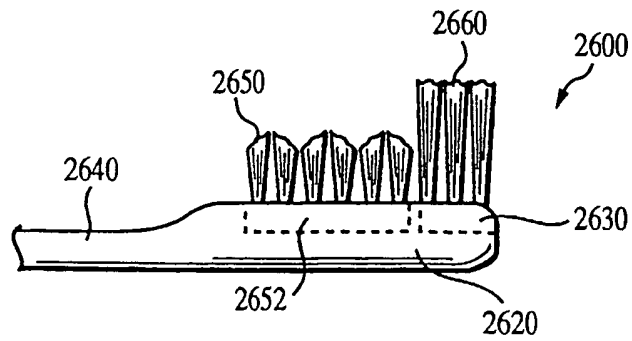


FIG. 40

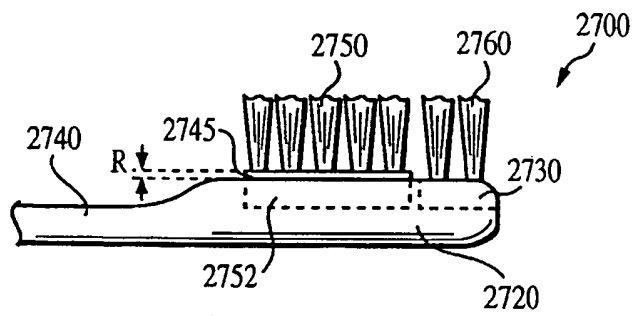


FIG. 41

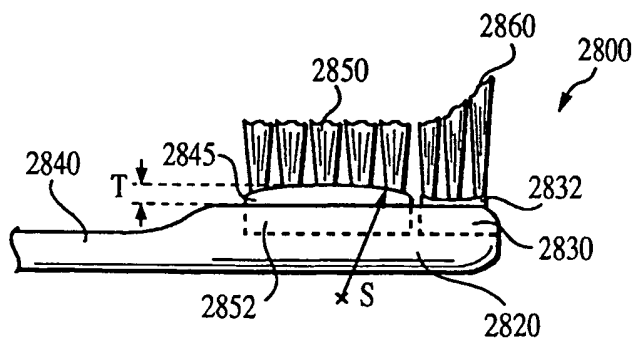


FIG. 42

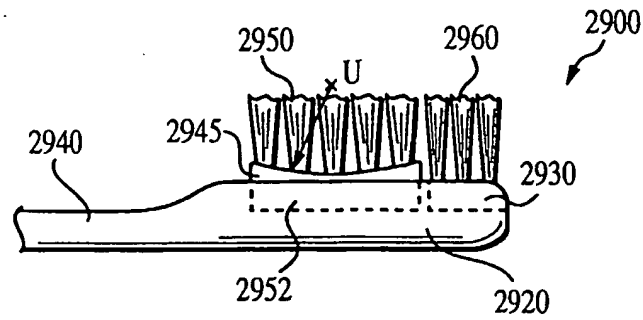


FIG. 43

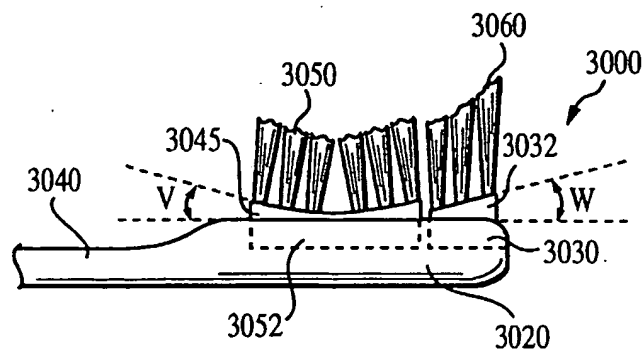


FIG. 44

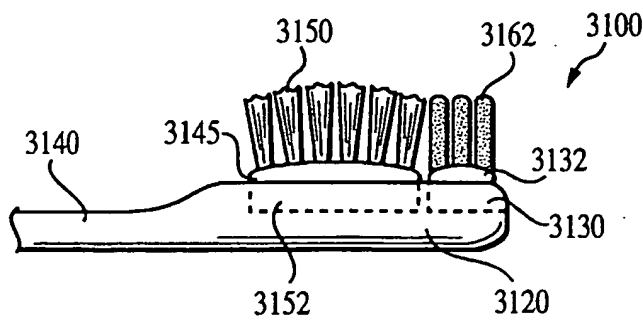


FIG. 45

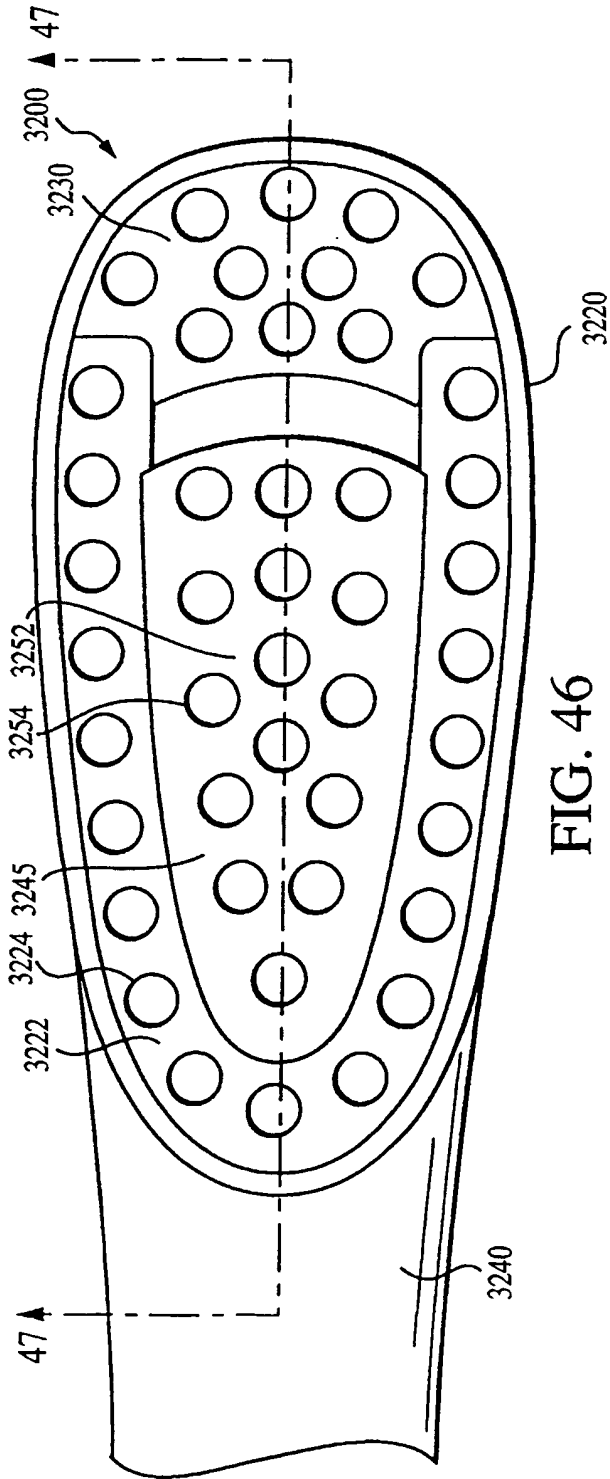


FIG. 46

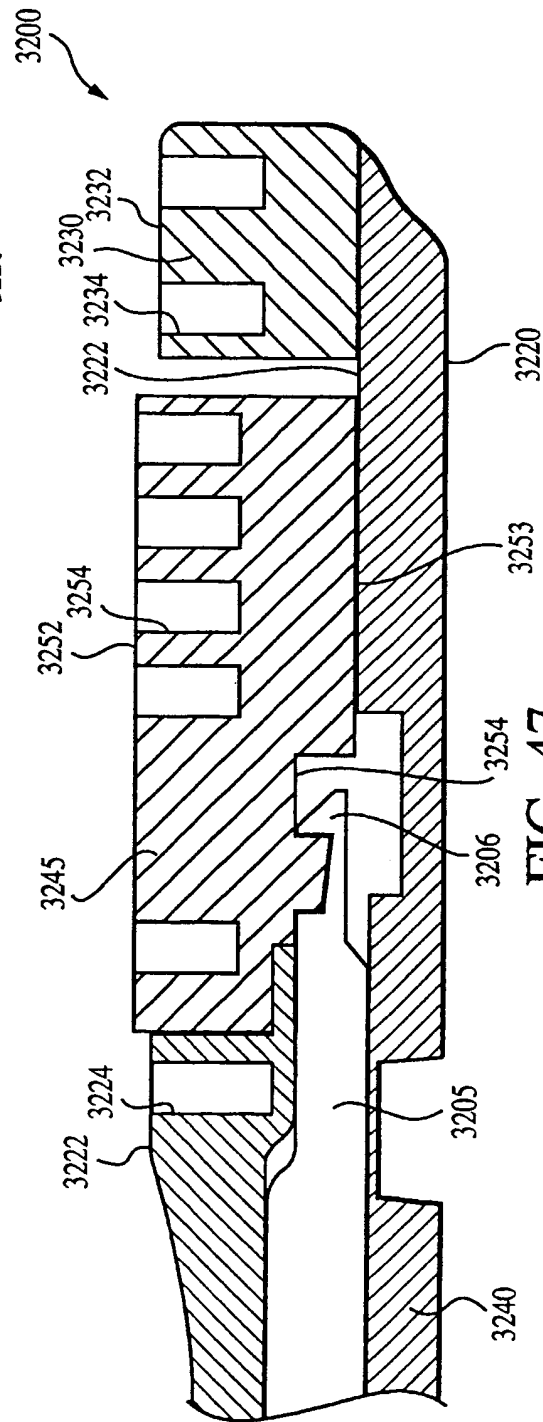


FIG. 47

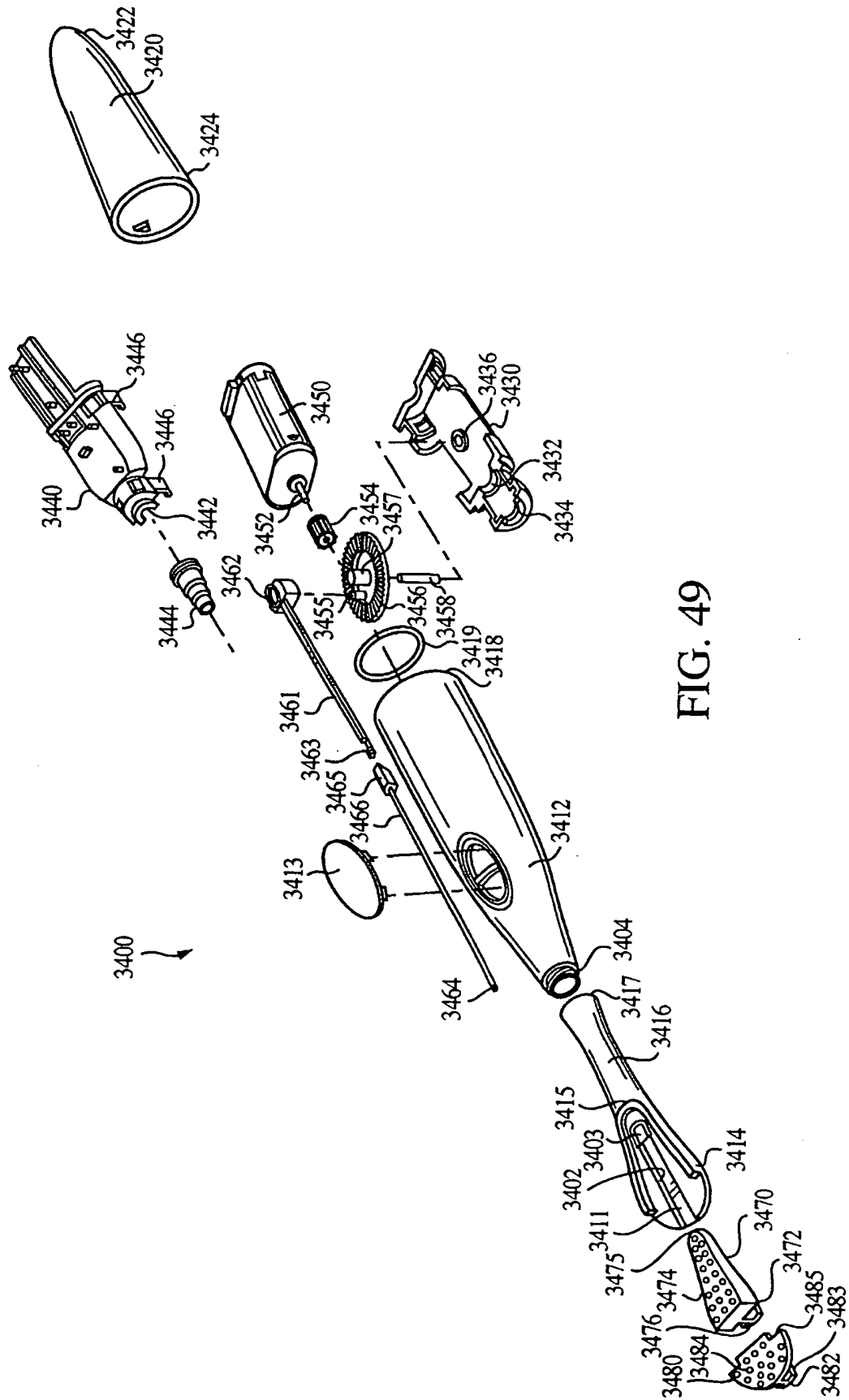


FIG. 49

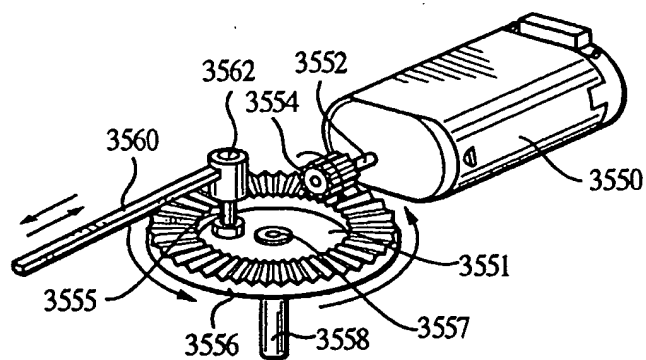


FIG. 50

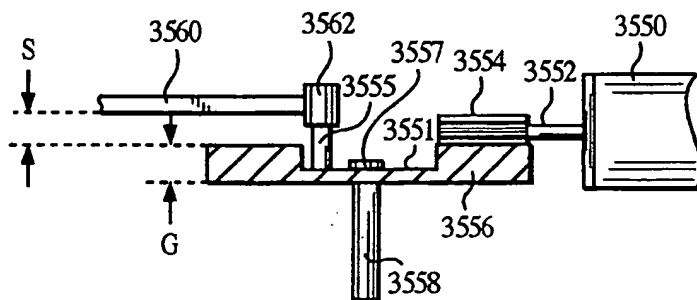


FIG. 51

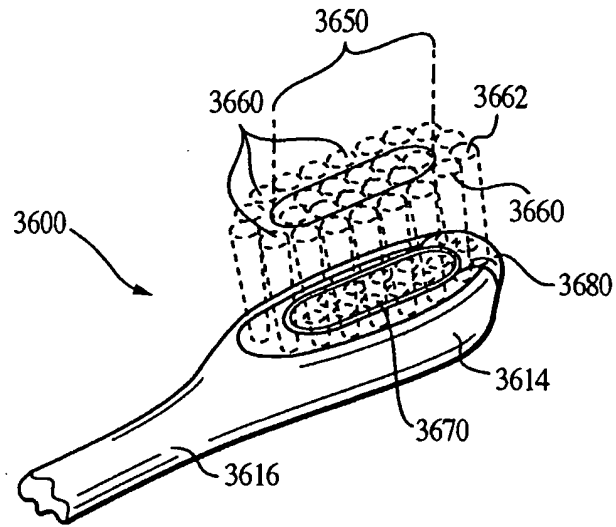


FIG. 52

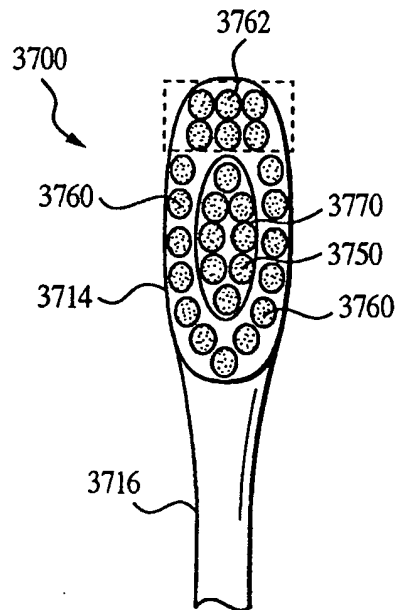


FIG. 53

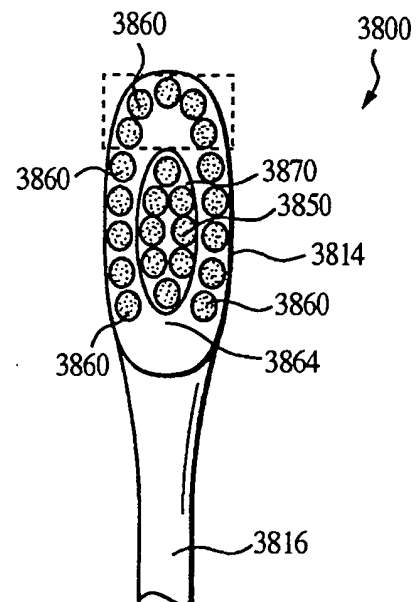
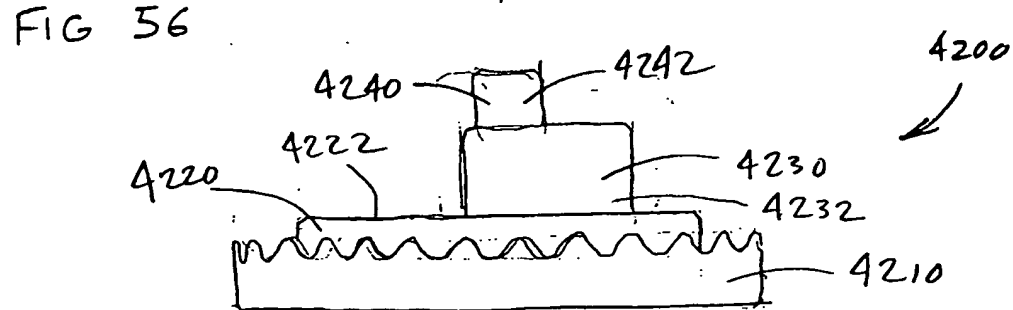
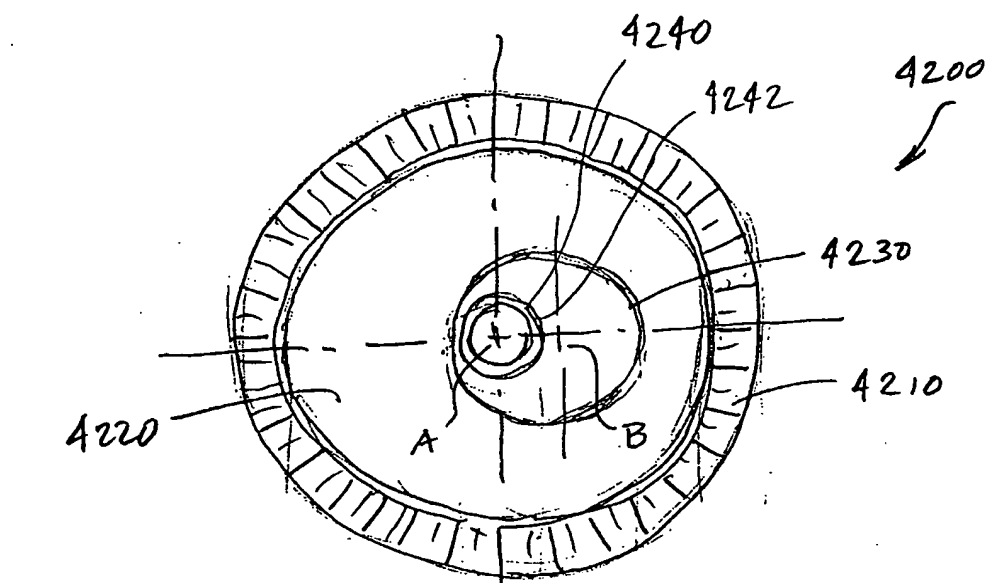
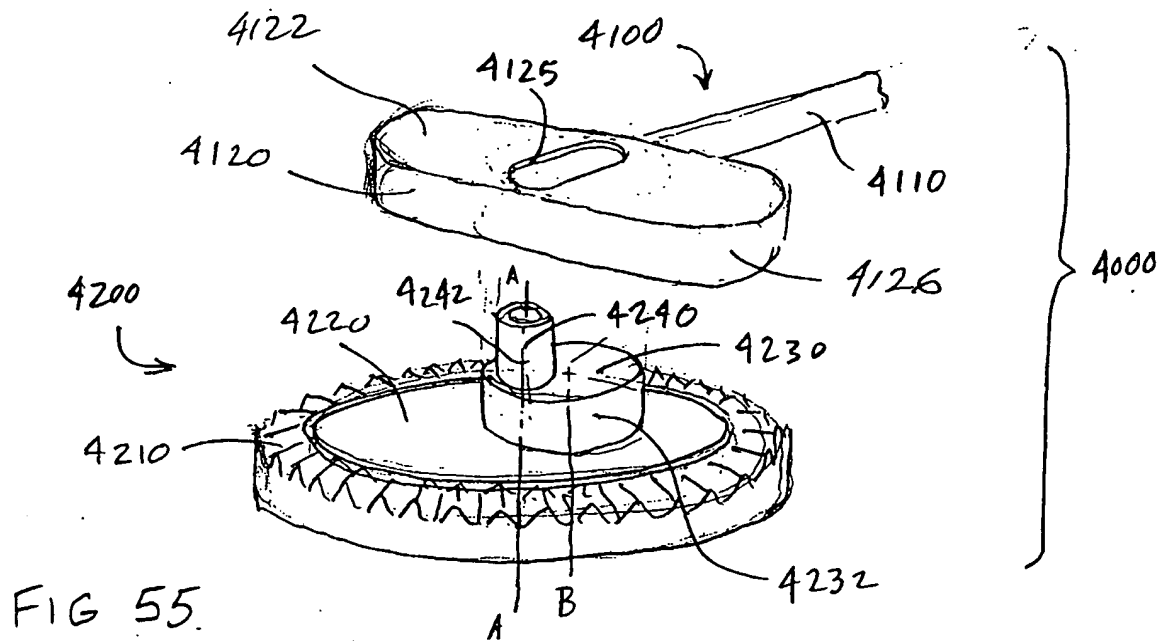


FIG. 54



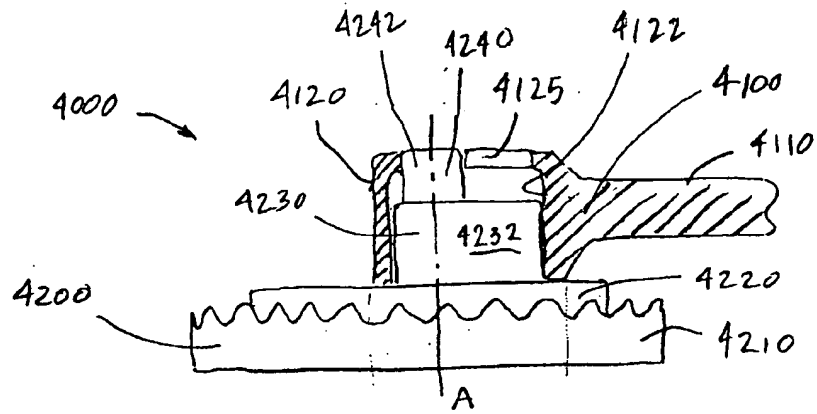


FIG 58

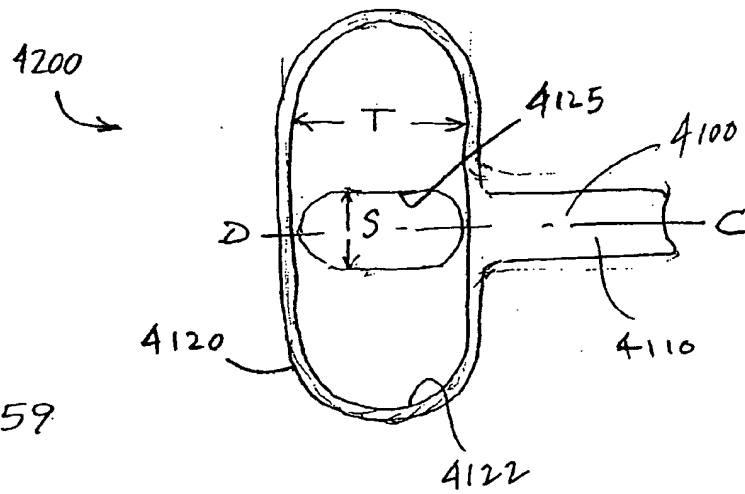


FIG 59

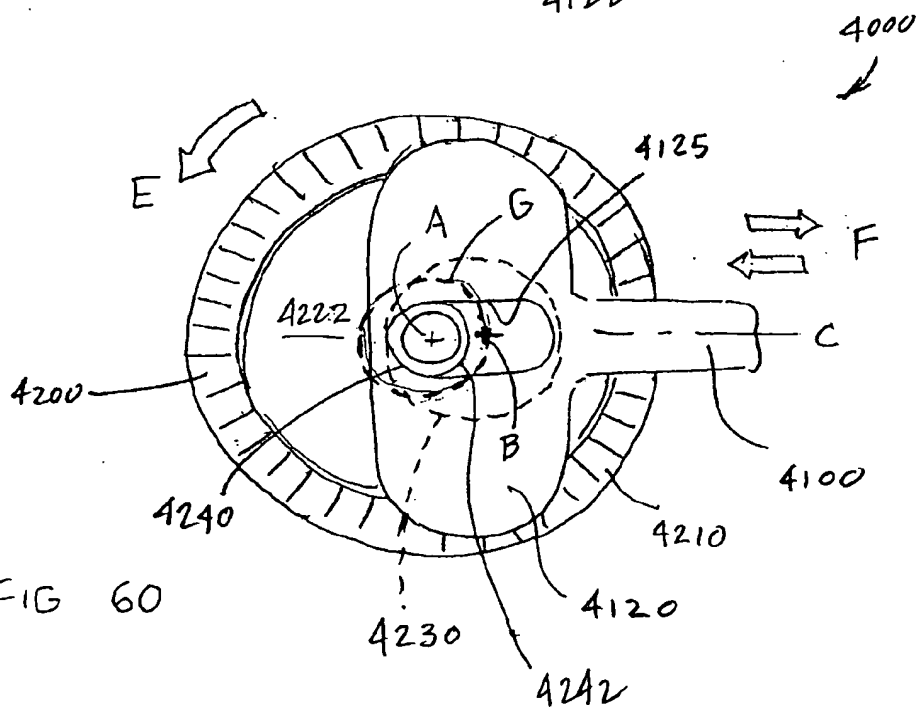


FIG 60

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 03/18368

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61C17/34 A61C17/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 A61C A46B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	-----	6-9
Y	US 6 237 178 B1 (KRAMMER MICHAEL ET AL) 29 May 2001 (2001-05-29) column 12, line 1-27 column 13, line 55-58 figures 3-5	

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Patent family members are listed in annex.

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Date of the actual completion of the international search

16 October 2003

Date of mailing of the international search report

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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